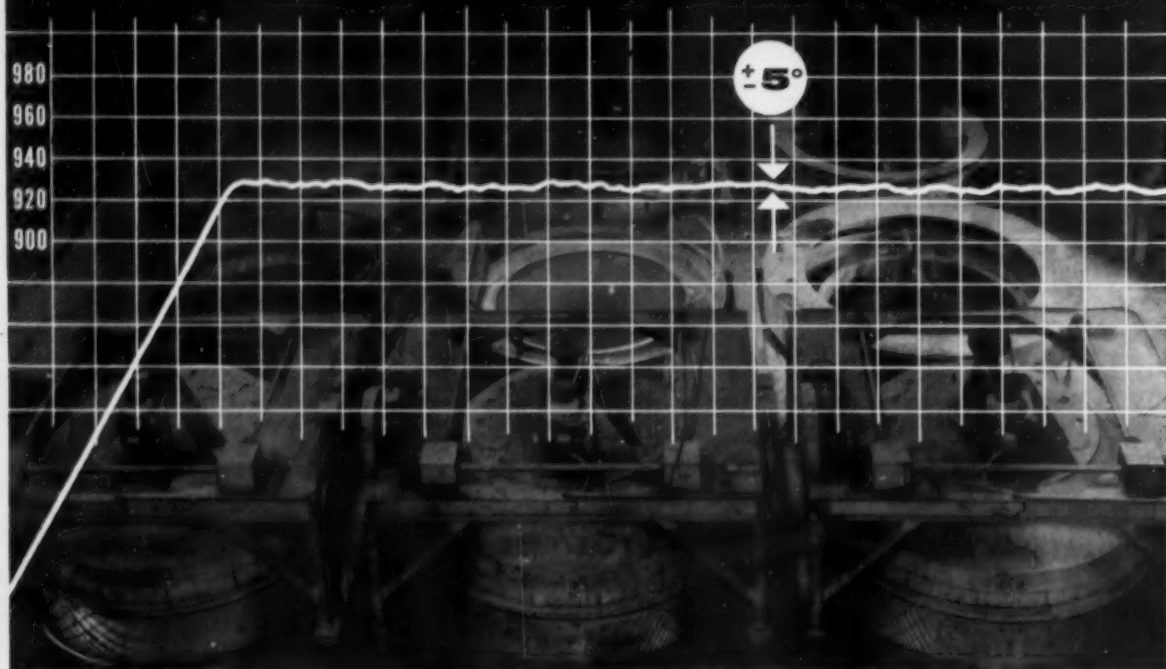


Metal Progress



MARCH 1955

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Metal Progress

Volume 67, No. 3

March . . 1955

The photomicrograph showing alpha formation in a beta titanium alloy, used for this month's cover, won the grand prize in the Metallographic Exhibit during the 1954 Metal Show in Chicago. Those who had a hand in its preparation are R. D. Buchheit, J. E. Boyd, A. A. Watts and F. C. Holden of Battelle Memorial Institute.

Ernest E. Thum, *Editor*
Marjorie R. Hyslop, *Managing Editor*
John Parina, Jr., *Associate Editor*
Floyd E. Craig, *Art Director*

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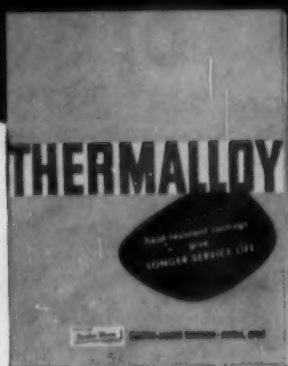
Centrifugal
Castings Bulletin



Muffles & Retorts
Bulletin T-239



Heat Treat Trays & Fixtures
Bulletin T-227



General Thermalloy
Catalog T-225



Conveyor Belt
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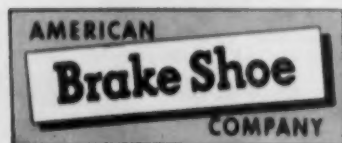


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Bulletin T-234

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resistant castings for use in many different types of equipment, you will find assistance in these bulletins. To obtain the bulletins pertaining to your problem, call your nearest Electro-Alloys representative or write Electro-Alloys Division, 6002 Taylor St., Elyria, Ohio.



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The three books reviewed are "Metal Data" by Samuel L. Hoyt, "ASME Handbook, Vol. I, Metals Properties", edited by Samuel L. Hoyt, and "ASME Handbook, Vol. III, Metals Engineering Design", edited by Oscar J. Horger. Both reviewers agree that all are worth-while compendiums in an area difficult to handle, but, being anthologies by different authors suffer from discontinuities in style and emphasis.

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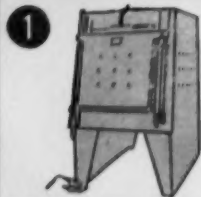
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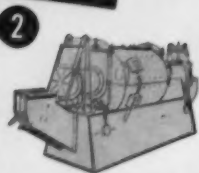
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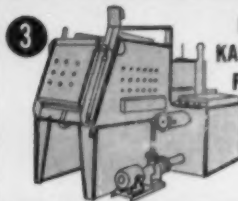
HERE ARE A FEW OF THE MANY TYPES
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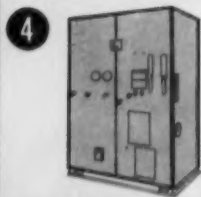
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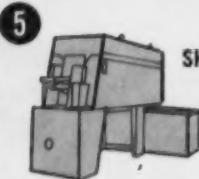
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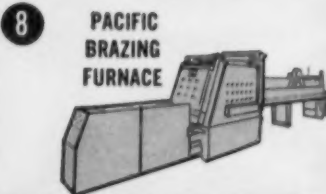
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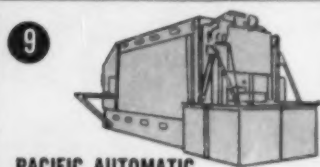
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As I was saying...



LAST month I returned to Cleveland—the land of snow and zero weather—for a week, and while I was there, received the following report from the California office:

"DEAR BOSS: Things have been happening since you left, and I thought I should drop you a note about the mail that passed you on the way and about new developments here. A note from Taylor Lyman says that Carl Gerlach and Jim Hontas (staff engineer and staff metallurgist on Metals Handbook) are doing a swell job and have the 24 committees all organized and are preparing for the second round of committee meetings; and that the second supplement to the Metals Handbook, to be published in August, will be of exceptionally high character,

judging from the membership on the committees preparing the material.

"Had a phone call from an exhibitor in the Western Metal Show advising us that he will require 35-hp., 220-volt, 3-phase for his equipment.

"Received additional orders for 5000 admission-inventions, making a total of 135,000 ordered by exhibitors. Looks like another fine attendance at the Western Metal Exposition.

"A note from Cleveland says that the 25,000 copies of the western edition of *Metal Showman* were shipped by Universal Carloading and should be available for distribution out of the Los Angeles post office Feb. 15.

"I have just figured the number of individuals on the Pacific Coast belonging to the 24 national technical societies co-sponsoring the Western Metal Congress, and the total is 20,950. Considering also that the exhibitors have submitted more than 14,000 names to receive information on the Western Metal Congress, I have notified the printer that the run on the next two Metal Show folders should be increased to 35,000 copies. Do you think we have enough money on deposit at the post office for the mailing?

"Was delighted to receive your wire and to know that you had selected an associate editor for *Metal Progress* and a director of education for the A.S.M. I am sure they will make very valuable additions to the present staff.

"Yesterday I had two phone calls inquiring about exhibit space. I sold the last two spaces available in the entire show. Just to make things more interesting I had a phone call this morning requesting space and it hurt a lot to have to say, 'Sorry, there isn't any more.'

"You received letters from Herbert French, Walter Jominy and Bradley Stoughton that they will attend the European Metallurgical Societies meeting. Their names have been added to the list of past presidents who wrote previously they would attend, and, along with the board of trustees, they will make a wonderful representation of national officers. You received six other letters from members indicating they had written to Cook's about definitely participating in the European meeting. Coupled with the other reservations, there is now a very formidable list.

"You received a note from Mr. Thum stating that *Metal Progress* is to be the topic of conversation at a meeting of the American Institute of Graphic Arts in New York. He and the managing editor (Marjorie Hyslop) and the production manager (George Loughner) all felt it advisable to attend the meeting, either to defend themselves or to receive accolades (I'll bet it will be accolades).

"I notice by the paper that it is around zero in Cleveland. Back here in Los Angeles the temperature is around 80; people are at the Sun Club around the Pool at the Ambassador.

"I won't write another letter because I know you will be coming back to the Land of Flowers, Sunshine and Tourists as soon as the 'Friendly Southern Pacific' can haul you back.

"Give my regards to everybody at the office. — EGG"

Cordially yours,

Bill

W. H. EISENMAN, Secretary
AMERICAN SOCIETY FOR METALS

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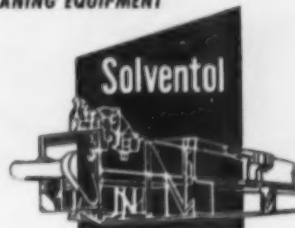
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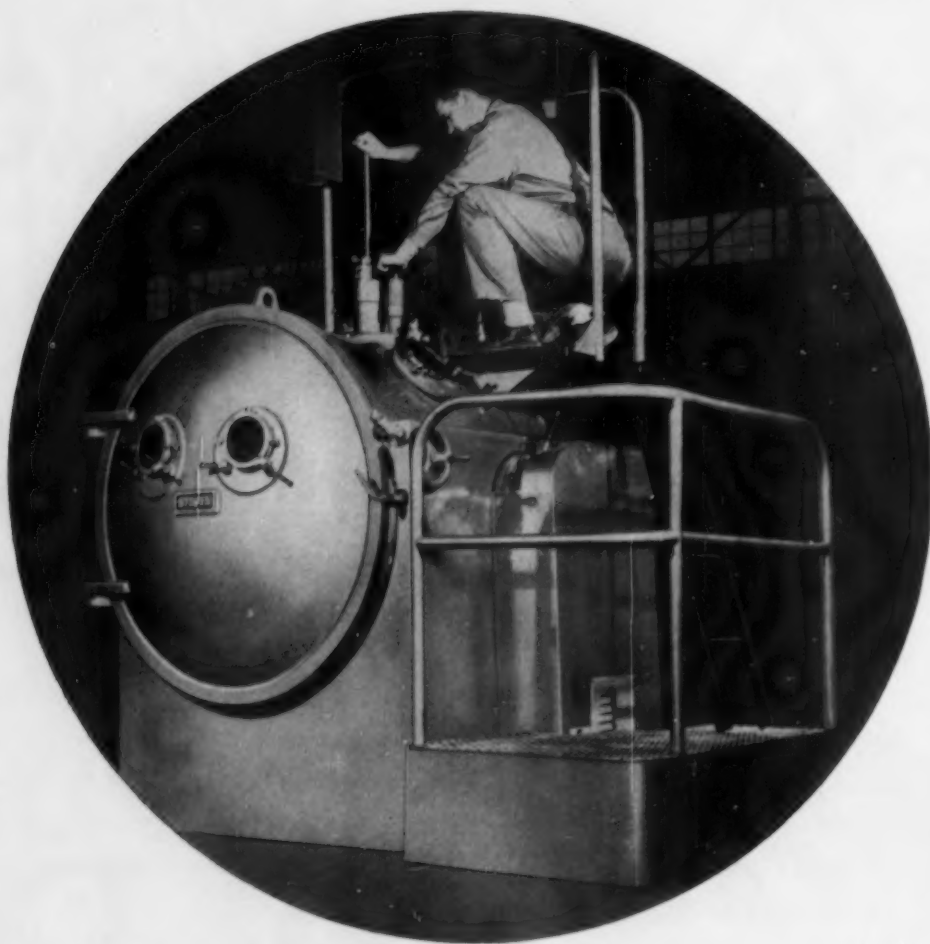
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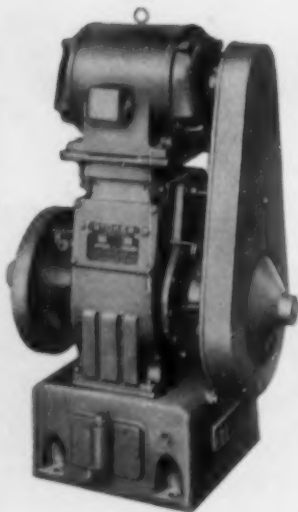


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Stokes manufactures a complete line of vacuum pumping equipment. This includes mechanical vacuum pumps, diffusion and booster pumps, vacuum valves and gages, and complete vacuum instrumentation. In engineered high vacuum equipment, Stokes builds vacuum metallizers, vacuum furnaces and other vacuum processing equipment.

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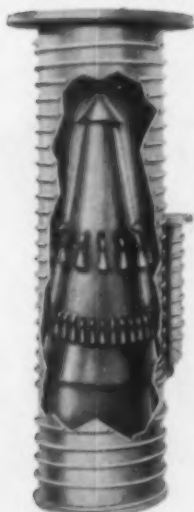
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and performance curves
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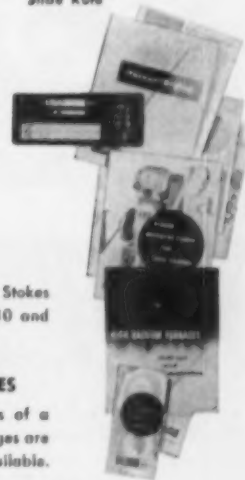
The new Stokes Ring-Jet Pumps embody a new concept of the diffusion principle. Size for size, they have pumping speeds of 10% to more than 100% above any other diffusion pump for a given heat input. Ring-Jet Diffusion Pumps are available in sizes of 4, 6, 10, 14 and 16 inches; Booster Pumps in sizes of 4, 6, 10 and 16 inches. Send for information listed.

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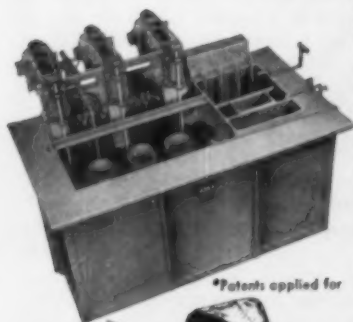
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Austempering this well-known electric shaver head (0.003" thick) in an Ajax furnace scored a \$50,000 a year saving over conventional quench and temper methods! Austempering produced tougher heads. Rejects due to cracks were reduced from 3.6% to .05%. Uniform hardness is obtained. Distortion is easily held within specified limits.

Grinding TIME Cut 80%



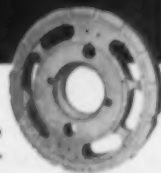
Martempered in Ajax furnaces and drawn to Rc 62-63, these SAE-52100 bearing races show an average out-of-round distortion of only 0.002-0.003" in heat treating. Grinding time was reduced from 50 minutes to less than 10 minutes per race.

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Lawn mower blades (SAE-1065) are austempered in a fully mechanized Ajax salt bath line to produce the critical combination of Rc 48-52 PLUS high ductility. Finished blades can be bent to horseshoe shape without cracking . . . and they're tough enough to cut nails! Production is 550 blades an hour. One man handles the entire job!

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Section size of this high alloy valve plate varies from 1/2" to 1 3/8". Conventional oil quench and temper methods failed to produce Rc 58-60 without cracking. Martempering and drawing in Ajax salt baths produced a hardness of Rc 60-64 . . . WITHOUT CRACKS!

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(Check box for each "no" answer. If "yes," leave blank.)



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Does my present equipment have infinitely variable speed control?	<input type="checkbox"/>	Can it obtain high magnification stress-strain recordings?	<input type="checkbox"/>
Can it control rate of loading?	<input type="checkbox"/>	Does it have unlimited testing stroke over the complete distance between upper crosshead and weighing table?	<input type="checkbox"/>
Can it control rate of strain?	<input type="checkbox"/>	Can it handle off-center loads?	<input type="checkbox"/>
Can it hold a stress or strain in the elastic range indefinitely?	<input type="checkbox"/>	Can it unload as accurately as it loads?	<input type="checkbox"/>
Can it utilize automatic load holding attachments?	<input type="checkbox"/>	Does it have simple controls?	<input type="checkbox"/>
Is its drive smooth enough not to affect the indicating system?	<input type="checkbox"/>	Is its accuracy independent of the operator's skill?	<input type="checkbox"/>

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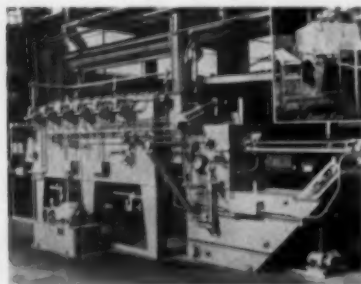
Division of
American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

engineering digest

OF NEW PRODUCTS

Radiant Tube Furnace

A gas-fired, vertical radiant tube furnace has been announced by Lindberg Engineering Co. It was designed to handle production loads of small parts requiring neutral hardening, carbonitriding, heavy and medium case gas carburizing and carbon restoration. The quenching arrangement is as follows: When the lead basket reaches the end of the heating chamber, a cylinder slowly and evenly



inverts the basket 180° allowing the work to trickle from the basket into the quench below. Each piece is individually quenched assuring a uniform hardness. A flight conveyor carries the pieces from the quench and drops them into baskets. Work is never removed from the protective atmosphere once it enters the heating chamber until it emerges from the quench. Heating is by means of 20 radiant tubes made of Inconel and suspended from the top plate. All tubes are fired at the lower end and are readily removable from the top plate without the need for cooling the furnace or interrupting the operations. Total input rating is 1,630,000 Btu. per hr. Maximum temperature rating is 1850° F.

For further information circle No. 626 on literature request card, p. 36-B.

Chromium Carbide

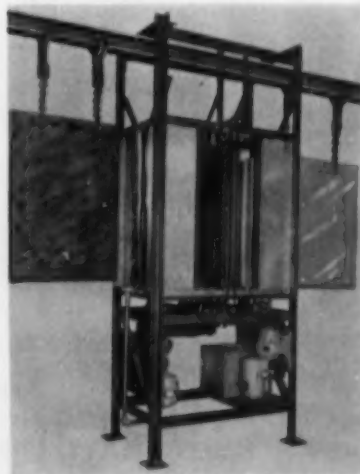
Chromium carbide, Carbology Dept. of General Electric Co. has announced, is proving to be a good structural material for load applying members and sample grips employed in high-temperature transverse rupture and tensile stress rupture testing, for anvil and Brale extensions in high-temperature hardness testing, and as

Brinell balls in elevated temperature hardness evaluations. Tests with chromium carbide 608 as a structural material indicate it has good strength at temperatures as high as 1500° F., resists creep and deformation at temperatures of 1800° F. or higher, and is very resistant to oxidation at 1800° F.

For further information circle No. 627 on literature request card, p. 36-B.

Cleaning

A new industrial scrubbing machine that cleans polished metal sheets before they are plated has been developed by the Fuller Brush Co., Machine Div. The metal plates, suspended by hooks, are carried through the cathode plate scrubber by an overhead monorail conveyor. A spray and cylindrical scrubbing brushes scour off residual material, and a clear water rinse leaves the plates clean as they leave the machine. Powering the scrub brushes are two ½



hp. motors. They turn the brushes by means of a chain drive. A ¼ hp. variable speed motor for the feed roll drive moves the cathode plates through the machine at a speed of from 2% to 8 fpm.

For further information circle No. 628 on literature request card, p. 36-B.

pH Indicator

A new panel-mounted indicator for continuous measurement of pH or re-



dox in manufacturing processes has been announced by Leeds & Northrup Co. The instrument is moisture-proof and gives accurate readings after less than 1 min. warm-up, without the use of desiccants. It is unaffected by line voltage surges, electrical pick-up and zero drift. The a.c. operated instrument can be used as a continuous indicator, with or without extra meter assemblies to duplicate readings. The indicator can also feed readings to a remote recorder.

For further information circle No. 629 on literature request card, p. 36-B.

Tensile Testing of Titanium

Baldwin-Lima-Hamilton Corp. has announced a close control of strain rate by using a Microformer-type extensometer on the specimen to operate a recorder and activate a strain-indicating pointer in a cabinet mounted behind the recorder. The pointer rotates in front of a pacing disk which rotates at a selected fixed speed. The operator keeps the strain indicating pointer turning at the same speed as the disk by regulating the rate of loading on the specimen. Micrometer load control on this 30,000-lb. capacity





You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge

deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-3.

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testing machine permits the operator to maintain a strain rate of 0.005 in. per in. per min. in testing titanium. After reaching the yield point, the extensometer is removed and the testing speed increased to produce fracture within a total time of 5 to 8 min., depending upon elongation characteristics of the material.

For further information circle No. 630 on literature request card, p. 36-B.

Pencil Test for Free Cyanide

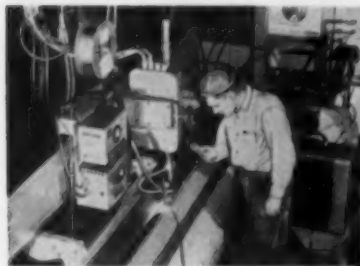
A special alloy pencil for testing and determining the approximate free cyanide concentration of all copper solutions has been announced by Pollack Products Co. The test can be made in seconds on plain cyanide-copper, Rochelle-copper and all high speed copper plating solutions. A simple dip of the pencil tip in the solution for about 15 sec. will indicate whether the free cyanide is too high, low or in the safe working range.



For further information circle No. 631 on literature request card, p. 36-B.

Inert-Gas Arc Welding

An electronically controlled heliarc voltage control has been announced by Linde Air Products Co. It maintains



a constant arc voltage to insure welds of uniform penetration and build-up. It also automatically turns both torch cooling water and inert shielding gas on at the start and off at the finish of a weld. It controls arc voltage by governing the distance of the torch from the work.

For further information circle No. 632 on literature request card, p. 36-B.

Vacuum Gage

A new, single-station thermocouple gage with printed circuit has been an-

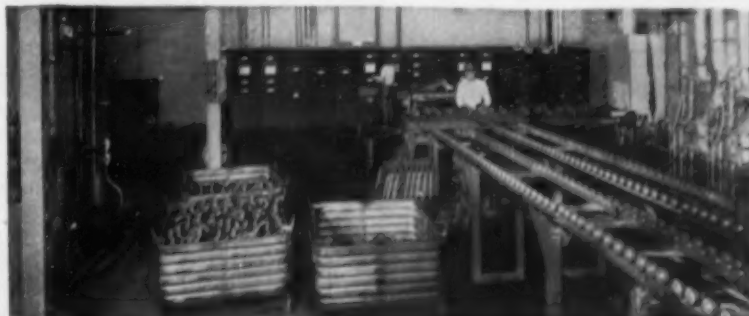


Wheelco Control Center



Brings automation to heat treating!

This specially engineered Wheelco Control Center provides complete instrumentation necessary for fully automatic heat-treating of oil well drill bits. Temperatures and heating cycles of carburizing, hardening, and drawing furnaces are precisely controlled from the central panel. Continuous, 24-hour process is completely mechanized. Wheelco Instruments simplify servicing . . . provide maximum standardization and interchangeability of "plug-in" components . . . assure dependability needed for continuous-flow, low-cost heat-treating. Let Wheelco's Instrument Engineering Service recommend profit-saving solutions to your special control problems.



WHEELCO INSTRUMENTS DIVISION

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nounced by Consolidated Vacuum Corp. It is compact and portable. The instrument is calibrated for air with one direct reading meter scale covering the range from 1 to 1000 microns

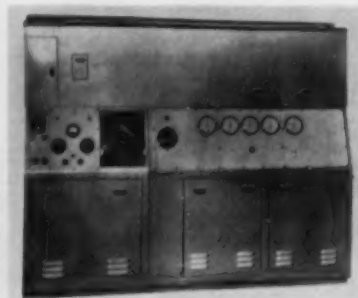


Hg. It measures the total pressure of condensable vapors and permanent gases present in a system. The gage is not harmed by exposure to atmospheric pressure.

For further information circle No. 633 on literature request card, p. 36-B.

Spectrometer

A direct reading spectrometer that incorporates new electronic, optical and mechanical design innovations, has just been announced by Jarrell-



Ash Co. It has a double optical system and focal deck so that it may be used photographically for qualitative or semi-quantitative analysis, simultaneously with or alternatively to the direct reading measurements. Complete analyses normally require less than 1 min. Results show standard deviations of 1 to 2%. The complete self-contained unit, consisting of a spectrometer, a dual source and the detection, integration and data presentation circuits, is housed in a compact metal cabinet.

For further information circle No. 634 on literature request card, p. 36-B.

Oil Filters

A new line of oil filters and two new cartridge-type filtering elements have been announced by Houdaille-Hershey of Indiana, formerly Honan-Crane Corp. All of the new filters feature quick opening lids. A new pleated paper cartridge called Flo-Pac, for full flow filtration, and a second element named Kleer-Pac, for

MARTINDALE

ROTARY BURS AND FILES

Made of high-speed steel. Produced in our own factory where uniform hardness is assured by heat-treating in electric furnaces on which the temperature is closely controlled by electric eyes.



Over 200 sizes and shapes (total over 75,000 pieces) are carried in stock for immediate shipment.

MOTOR-FLEX UNITS



Martindale Motor-Flex Units are made in 7 Models—24 Combinations. They vary from 1/10 to 1/2 H.P. with various motor speeds. Available in bench, pedestal or overhead suspension types.

Complete line of attachments.

METAL-WORKING SAWS



Made of 18-4-1 High Speed Steel in 4 types for Screw-Slotting, Metal-Slitting, Copper-Slitting and other cutting operations on both ferrous and non-ferrous metals.

Diameters range from 1 3/4" to 4" and stock tools are made with various numbers of teeth and in a wide variety of thicknesses.

Write for 64 page Catalog No. 29 covering above Saws, ROTARY BURS and FILES, and many other products for maintenance, safety, and production.

MARTINDALE ELECTRIC CO.

1372 Hird Avenue, Cleveland 7, Ohio



Hardened areas show darker
at ends of rocker arm.

**JUST
2 $\frac{3}{10}$
SECONDS**

**for accurate
selective
hardening
of this
rocker arm**

...using a Lindberg 50 KW High Frequency Unit



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Booth 666, and at ASM Western
Metal Exposition Booth 334

In Detroit, a leading manufacturer of prestige autos increased production of rocker arms 300% by switching to a Lindberg 50 kw high frequency unit with a new work fixture. Production is now 1550 per hour . . . with no rejects due to unit failure.

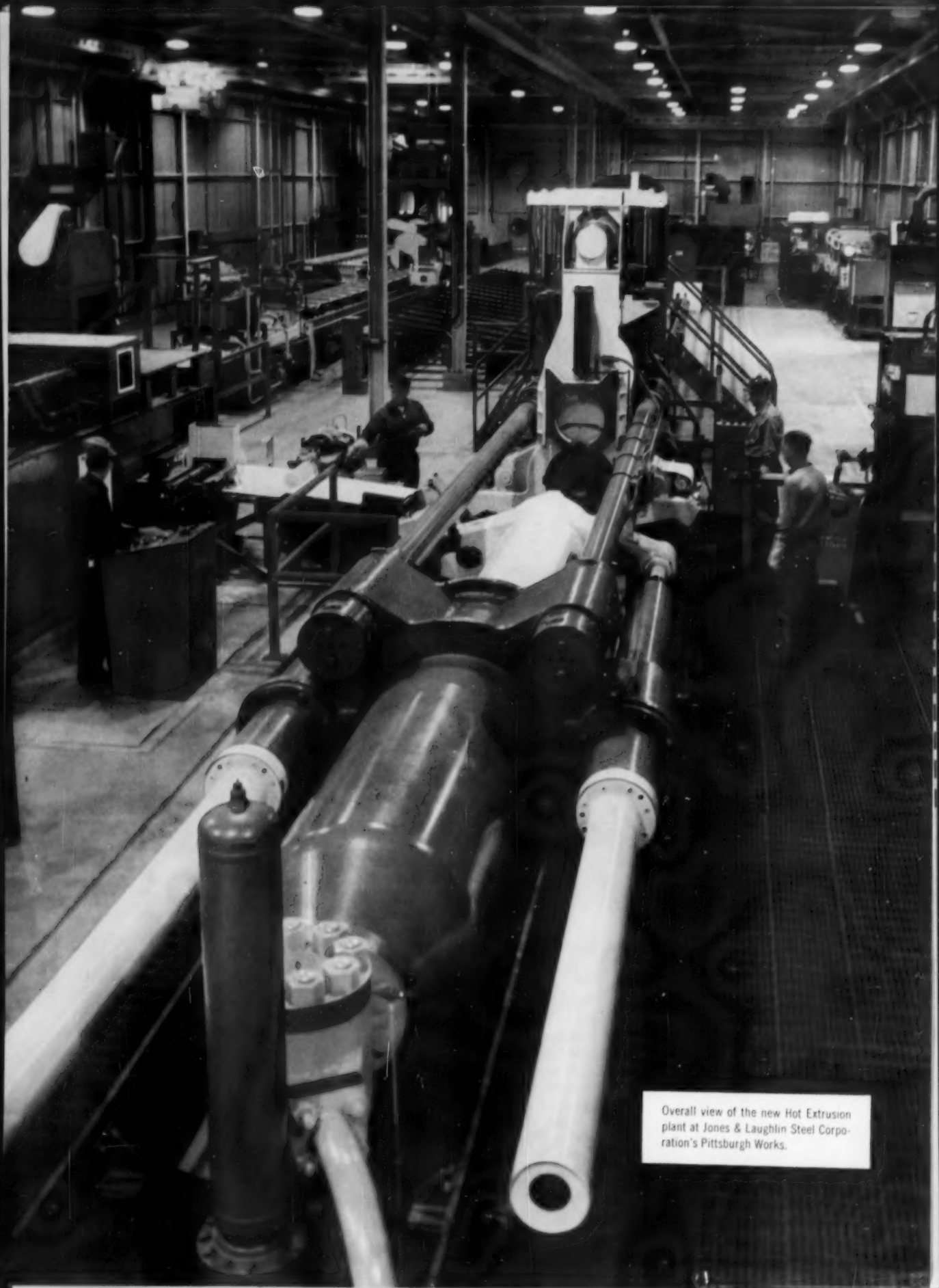
Selective hardening of these pearlitic malleable iron rocker arms provides wear resistance from valves

and push rods. A sharp cutoff of the hardness is necessary because the center hole must be kept soft for further machining.

Lindberg high frequency units give continuous 24 hour a day operation with a maximum of dependability. If you have an induction heating application, you'd do well to talk things over with a Lindberg engineer.

LINDBERG  **HIGH FREQUENCY DIVISION**

Lindberg Engineering Company • 2448 West Hubbard Street • Chicago 12, Illinois



Overall view of the new Hot Extrusion plant at Jones & Laughlin Steel Corporation's Pittsburgh Works.

NOW IN PRODUCTION

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[HOT EXTRUDED and COLD DRAWN]

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NEW PLANT

This modern new plant, now in production, can tailor-make Extruded Sections (hot extruded and cold drawn) to your specifications. Here, complex sections that cannot be rolled can be custom-made for you . . . quickly and economically.

J&L's ingenious new equipment makes possible the production of sections that are preformed to the predominating cross section of the part you wish to produce. The range of sections that can be produced is almost unlimited.

Quantities also are extremely flexible. Even the production of a single extrusion of less than 100 lbs. is practical.

In addition, J&L's Extruded Sections possess the physical benefits and accurate tolerances derived from cold drawing. And, you can obtain them in a wide range of analyses.

Complete information is available now. Send us your inquiry—today.

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STEEL CORPORATION — Pittsburgh

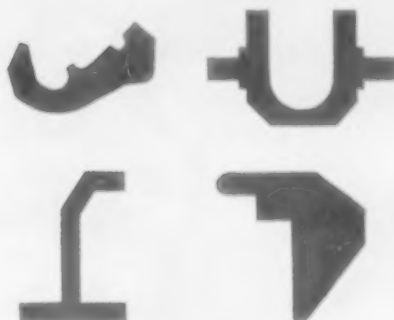
**J&L
STEEL**



Close-up of the 1000-ton hot extrusion press at Jones & Laughlin Steel Corporation, Pittsburgh. Hot billet is being pushed into the die container. The ram then forces it through the die.



Examples of sections that can be produced to your order. More intricate sections are also possible. The section you need is custom-made to your requirements.



**J & L's Extruded Sections
help speed your production
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With the new Baird Spectromet*, spectrochemical analysis is possible directly on the floor of the foundry and in the meltshop. Thirty to forty seconds after the sample is burned, the concentrations of six elements in the sample are read from indicators located on the face of Spectromet*. The indicator readings can be easily and rapidly translated into accurate corrections in the melt and give constant control of the contents of the melt.

The speed of the instrument's operation permits as many as 180 determinations per hour providing practical analytical data at low cost per sample.

Sealed optical and electronic compartments provide a built-in laboratory environment. Maintenance is reduced to a minimum.

For more information why Spectromet* can help serve your analytical needs, write for free technical Bulletin #42.

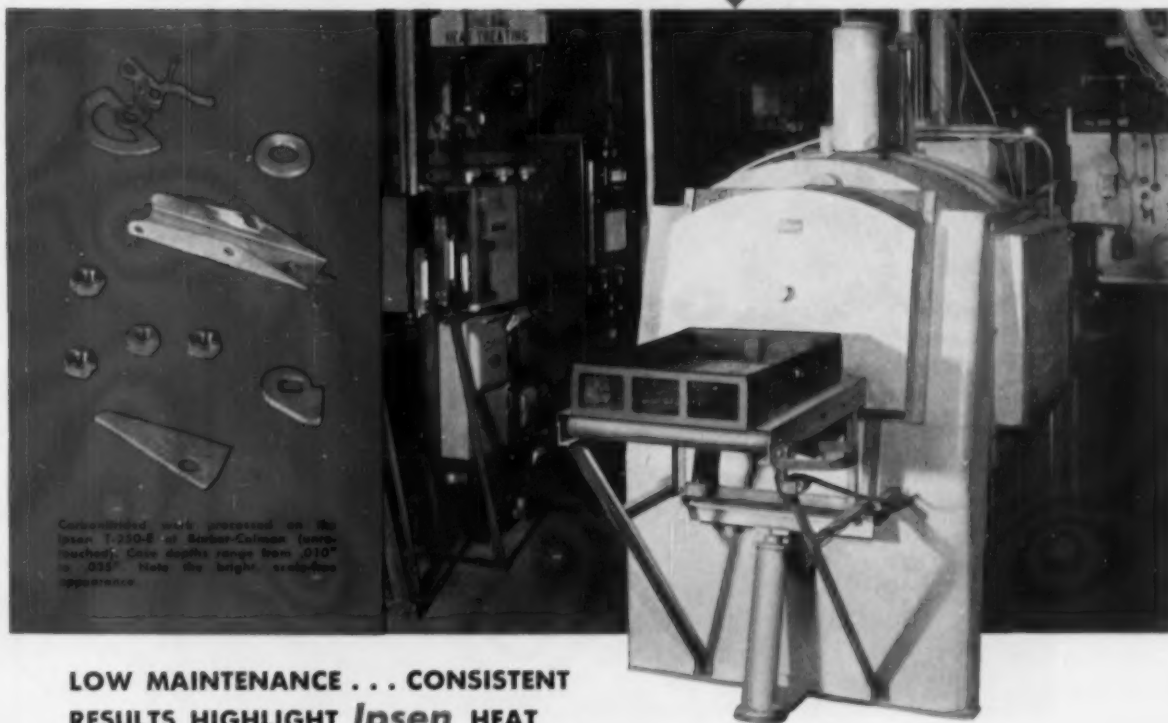
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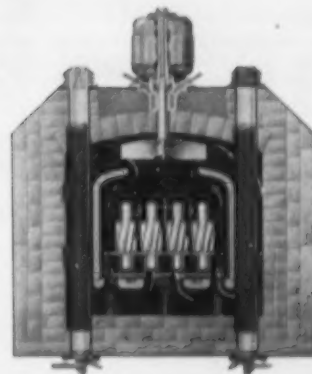


LOW MAINTENANCE . . . CONSISTENT RESULTS HIGHLIGHT *Ipsen* HEAT TREATING INSTALLATION AT BARBER-COLMAN

Total maintenance expense . . . \$395.56. Total hours of operation . . . 13,200. Type of work . . . 65% bright carbonitriding, 20% bright carburizing, all other, 15%. *Less than 3 cents per hour for maintenance.* That's the report from the Barber-Colman Heat Treating Department on this Ipsen T-250-E Furnace since its installation.

Now . . . Ipsen's latest 100% Forced Convection design cuts low maintenance costs even more.

GET THE FACTS—See for yourself how Ipsen "Controlled-Atmosphere" Furnaces can cut your heat treating costs. We'll be glad to send you all the details.



IPSEN INDUSTRIES, INC., 723 So. Main St., Rockford, Illinois



Controlled Atmosphere
Heat Treating Units



Controlled Atmosphere
Tempering Units



Automatic Washers

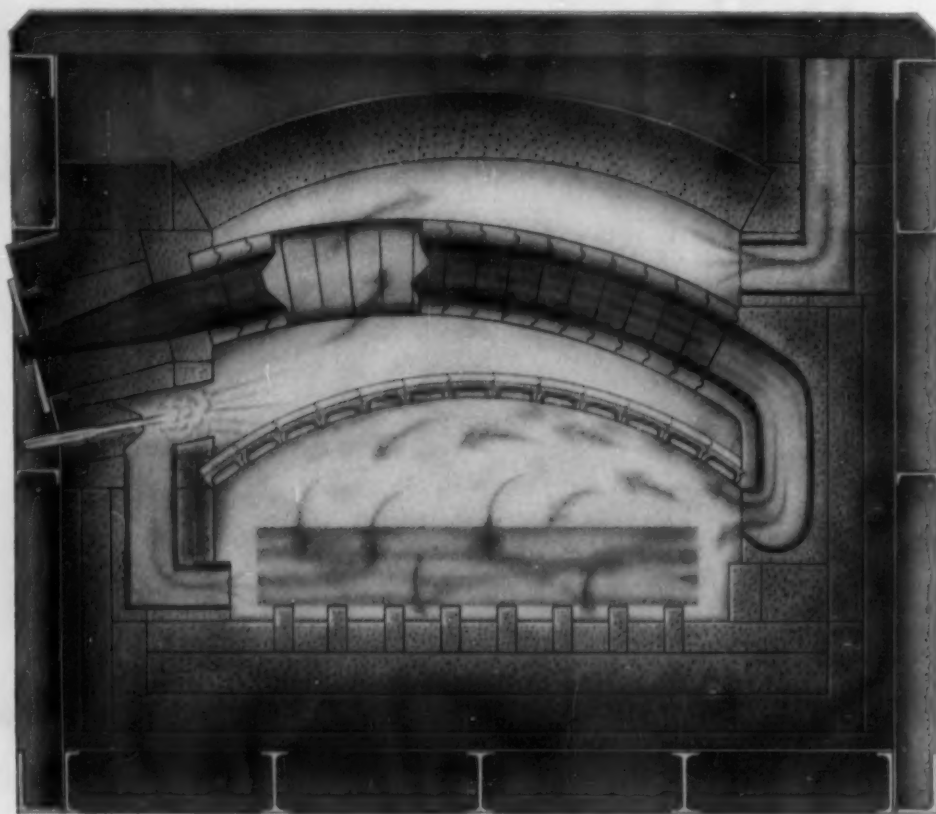


Dewtronik and
Carbuetronik Controllers



Atmosphere Generators

Another Norton *R_x* on the job!



Cross-section of a Lithium Company two-stage hot atmosphere recuperative furnace for scale-free heating of ferrous and non-ferrous metals for precision forging and rolling. The segmented conduit, a Lithium Company design, is made of Norton CRYSTOLON tongue and groove tiles. Fired shapes of this same material form the side walls. Burner block is of ALUNDUM refractory material.

Lithium Company specifies long-life ALUNDUM and CRYSTOLON* refractory shapes for its atmosphere furnaces*

The Lithium Company of Newark, N. J., well-known builder of atmosphere furnaces, reports excellent results from Norton refractories.

The Lithium designed refractory shapes are Norton CRYSTOLON Silicon Carbide. They were selected for their hot strength, high refractoriness, thermal conductivity, and low thermal expansion. They give long, trouble-free service life at temperatures up to 2900°F. ALUNDUM refractory material was the choice for the burner block because of its high refractoriness and resistance to

chemical influences at temperatures up to 3450°F.

For your own furnace operations

It will pay you to investigate how Norton R's — *engineered and prescribed* refractories — can help you save time, work and money. See your Norton Representative or write to NORTON COMPANY, Refractories Division, 322 New Bond Street, Worcester 6, Mass. Canadian Representative: A. P. Green Fire Brick Co., Ltd., Toronto 5, Ont.

NORTON

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Engineered... R... Prescribed

*Making better products...
to make your products better*

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depth-type filtration for detergent-type oils, have been offered.

For further information circle No. 635 on literature request card, p. 36-B.

Tube Furnaces

New high-temperature electric tube furnaces, available for, two and four tubes, have been announced by Burrell Corp. They are recommended for high temperature combustion in the determinations of carbon or sulphur in ferrous and nonferrous metals. A large air space between inner and outer housings provides extra cool operation with continuous operation at high temperatures. The entire in-



sulation unit is replaceable. Brief heating-up time is achieved through a combination of extra large silicon carbide elements, ample transformer size and heavy insulation of low heat capacity. Working temperatures can be changed quickly, up or down, to suit different jobs. For high temperature testing, continuous operation up to 2650° F. is recommended for good element life. Construction is of heavy gage steel, finished in grey hammer-tone. Tube holders are built in. Three sizes are available for one, two or four tubes up to 1½ in. o.d.

For further information circle No. 636 on literature request card, p. 36-B.

Beryllium-Copper Wire

Little Falls Alloys has announced a new high-conductivity beryllium copper wire. It is composed of 0.5% beryllium, 2.5% cobalt and the balance copper. The wire has 65 to 70% conductivity of copper and will resist fatigue from flexing and vibration and withstand higher temperatures than ordinary copper wire. It comes with a light silverplating which makes it easy to solder. This plating also makes it possible to apply the insulating materials that require higher curing temperatures than tinned wires can stand. It is available in all fine wire gages in solid or stranded form.

For further information circle No. 637 on literature request card, p. 36-B.

Iridium Radiography

The Gamma Corp. has announced a new device for the remote handling of iridium 192 in industrial radiography. The iridium isotron allows sources of up to 75 curies to be exposed at distances up to 50 ft. from the operator, who can expose the source while remaining behind a concrete wall or personnel shield. The isotron is designed for panoramic exposures, where several specimens are arranged around the source and shot simultaneously, and internal exposures, where the source is exposed within a cavity in the specimen and the film wrapped around the outside. The machine is portable, requiring no power, and weighing only 125 lb. Exposure times compare with those for X-ray equipment.

For further information circle No. 638 on literature request card, p. 36-B.



Ultrasonic Inspection and Cleaning

Met-L-Chek Co. has announced the use of ultrasonic vibration with their visible penetrant inspection method. It can also be used for general surface

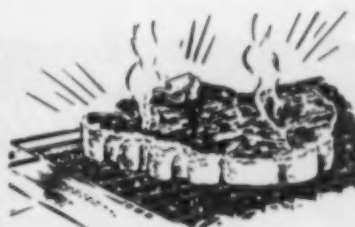


cleaning when the ultimate in soil removal is desired for plating, painting and other processing. High speed vibration greatly accelerates penetration, water washing to remove excess penetrant dye and development of flaw indications.

For further information circle No. 639 on literature request card, p. 36-B.

X-Ray Microscope

General Electric Co. has announced an instrument that will magnify and X-ray subjects smaller than the human eye can see. The device magnifies up to 1500 X and permits the study of grain structure in metals. The principal feature of the instrument is



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Steak...*

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**THE TOUGHEST STEAK
CAN "SIZZLE", BUT OFFER
LITTLE SATISFACTION TO
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YOU HEAR A LOT OF "SIZZLE" today about rolled heat resisting alloys, too. What you're really interested in is performance, though, and that requires not one but a combination of properties. That's where **RA** comes in. **RA** alloys are tailored to have the combined properties required for performance at elevated temperature.

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**A NEW HIGH QUALITY
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 13 STANDARD COLORS**

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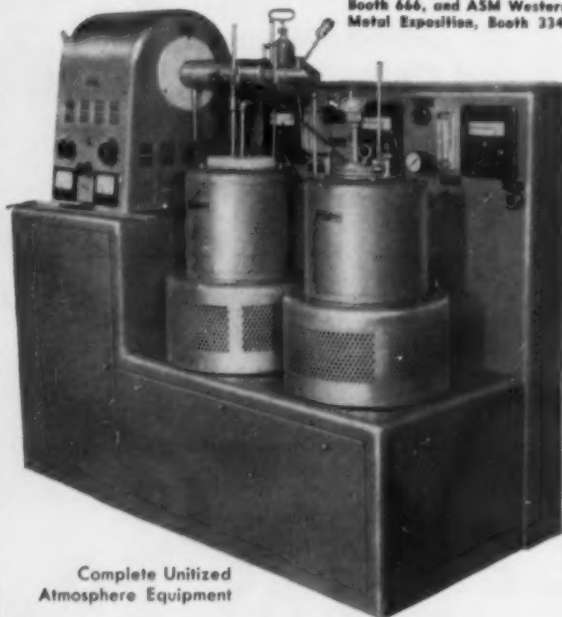
Colorweld COIL

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New From Lindberg

UNITIZED ATMOSPHERE FOR RESEARCH

Visit Lindberg at ASTE Show,
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Complete Unitized
 Atmosphere Equipment

EQUIPMENT: A newly developed laboratory generator is used in combination with small laboratory furnaces. This new generator is the first offered to efficiently produce the limited quantities of atmosphere needed in laboratory work. A pot crucible furnace, type CR-5, is used to act as a heat source for the catalytic reaction. The atmosphere produced may be employed in various types of furnaces.

PERFORMANCE: By completely dissociating raw liquid anhydrous ammonia over a heated catalyst, a bone-dry Hyam atmosphere of 75% hydrogen, 25% nitrogen is produced at the rate of 35 cu. ft. per hour. The dew point is minus 60° F.

APPLICATIONS: Research and control laboratories, especially in the fields of metal, ceramics and chemicals, will find this unitized atmosphere useful for experimental purposes. It may also be used for bright hardening, tempering, nitriding and brazing on short production runs.

For detailed information on this equipment, see your Lindberg laboratory equipment dealer, or write for our "Report on the use of Protective Atmospheres in Laboratory Type Furnaces."

LABORATORY EQUIPMENT DIVISION

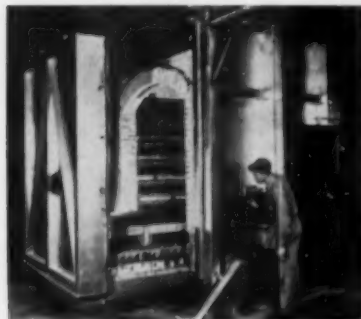
LINDBERG ENGINEERING COMPANY
 2448 West Hubbard Street • Chicago 12, Illinois

an electrostatic lens system that provides an X-ray source 1/300 the size of a human hair. This is important because the larger the X-ray source, the lower the potential magnification of specimens.

For further information circle No. 640 on literature request card, p. 36-B.

Furnace

The Waltz Furnace Co. has announced a car-bottom electric furnace for preheating and stress relieving stainless steel valves prior to welding.



Its temperature range is up to 1800° F. It is 6 ft. long by 5 ft. wide by 5 ft. high. Material is treated on a car driven by electric motor.

For further information circle No. 641 on literature request card, p. 36-B.

Hardness Tester

George Scherr Co. has announced the development of a combined hardness tester and measuring microscope. A Leitz micro-hardness tester makes indentations invisible to the naked eye by means of a Vickers diamond. This small indentation is visible at 400X magnification. Measurement of the indentation is by means of a graduated ocular enabling the measurement of the indentation to 0.0005 mm. When intended for use as a measuring microscope, the 100X magnification lens is used. A micrometer cross



slide stage, equipped with 1 in. micrometer drums graduated directly in 0.0001 in. without vernier, with a total measuring range of 2 by 1½ in. has been fitted to the instrument.

For further information circle No. 642 on literature request card, p. 36-B.

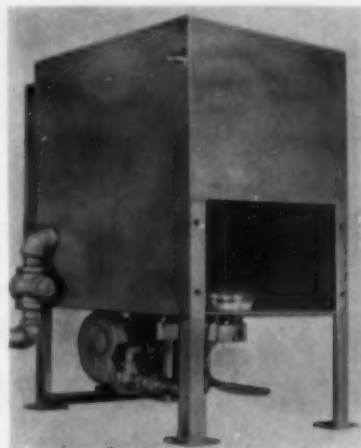
Input Controller

Automatic Temperature Control Co. has announced improvements in design of their input controllers. Timing cams and contact arms are now made of precision-molded nylon, substantially reducing wear, noise and friction. Need for lubrication is eliminated by an oiled-for-life rotor on the synchronous motor. Selector knob maintains setting through heavy wire spring stressed against dial cam to absorb vibration. Larger contacts permit heating loads up to 4.6 kw. without the use of external contactors.

For further information circle No. 643 on literature request card, p. 36-B.

Parts Washer

A small parts washer that is fired by a radiant heat system has been announced by Burdett Mfg. Co. It is available in 100,000, 129,000 or 158,000 Btu. per hour. Tank capacity is



about 50 gal. Temperature of the cleaning liquid will rise from 50 to 200° F. in approximately 1 hr. The tank is of heavy gage welded steel construction with structural reinforcements.

For further information circle No. 644 on literature request card, p. 36-B.

Heat Exchangers

Shell and tube heat exchangers have been announced by Heil Process Equipment Corp. for use in maintaining the low (20 to 30° F.) operating temperatures required for the hard coating type anodizing processes.

These can be adapted to standard plating units. Less heat transfer surface was required because of the greater heat transfer rate obtained from the forced flow through the im-



pervious graphite external exchangers. Other favorable features are the elimination of possible stray current attack and the use of smaller tanks, since no tank space is used by this type of exchanger.

For further information circle No. 645 on literature request card, p. 36-B.

Spectrometer

Baird Associates has announced modifications in its direct reading spectrometer to provide fast spectrochemical analysis on the foundry or metal fabricating floor. It will give percentage readings on six elements in less than 2 min. It can give continuous quality control analyses of a metal production stream, and is adaptable for use with mixtures containing bases of either ferrous or non-ferrous metals. Its critical instruments are sealed in a leaktight tube 12 in. in diameter and 12 ft. long. The instrument uses an original 4-in. diffraction grating having a 3-meter focal length and 15,000 lines per in. A first order spectral range of approximately 2000 Å is available at the focal curve. Problems requiring second order spectra can be set up with 1000 Å available.

For further information circle No. 646 on literature request card, p. 36-B.

Band Saw

Two new metal cutting band saws have been announced by W. F. Wells & Sons. These new saws are equipped with a variable speed drive, providing speeds from 50 to 200 fpm. A graduated metering valve permits choice



For the First Time

TUBING MADE FROM **COPPER,**

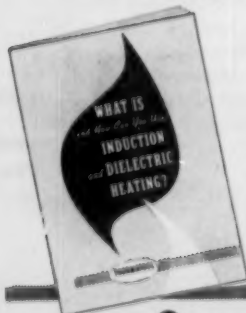
ALUMINUM, BRASS, STEEL STRIP
IN ANY DIAMETER
INTERCHANGEABLY *with the*

NEW THERMATOOL
Welding Process



PAT.
PENDING

If you use or make tubing in any form, you owe it to yourself to investigate this far-reaching development in tube welding which permits the manufacture of all kinds of tubing from strip, even with copper with 100% conductivity, on a continuous basis at great savings in time and money. No change in the weld head is required to change diameters or type of metal!



EXCELLENT DRAWING QUALITIES

The above samples of 1¼ inch aluminum tubing made by the Thermatool Method and drawn in steps down to ¾ inch with no effect on the weld, is graphic evidence of another reason why engineers, tube mill manufacturers, and producers are placing orders for one of the most important basic developments in tubing in years. Send for details of the Thermatool Method of tube welding *today*.

● If you are interested in high frequency heating in any form, send for this interesting booklet which explains many other facets of Induction and Dielectric Heating including the use of motor generators and vacuum tube units of all capacities and sizes made and sold by New Rochelle Tool Corp.

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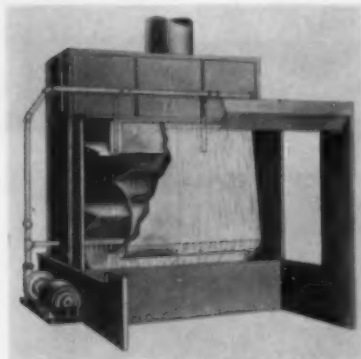
ENGINEERING • DEVELOPMENT • MANUFACTURING • MARKETING
OF INDUCTION, DIELECTRIC AND ELECTRIC HEATING EQUIPMENT

of proper blade speed and pressure. Both of these new models provide full hydraulic operation, all welded steel bases, welded one-piece cutting head and large capacity coolant and chip tray.

For further information circle No. 647 on literature request card, p. 36-B.

Spray Booth

The Despatch Oven Co. has announced a new water spray paint booth. Using a new type of baffle chamber, the water wash paint spray booth provides a positive air cleaning action that prevents paint pigments and volatiles from reaching the ex-

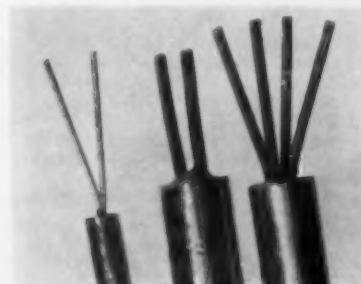


haust stack or the outside of a building. The new air scrubbing chamber features a specially-designed spray header mounted within two curved baffle plates. When water is pumped into the header it sprays forth in three directions from three rows of orifices and strikes the baffle plates, building up a violent spray turbulence that removes most of the paint.

For further information circle No. 648 on literature request card, p. 36-B.

Thermocouple Wire

Thermo Electric Co. has announced its new magnesium-oxide insulated metal clad thermocouple and thermocouple extension wires. They are made



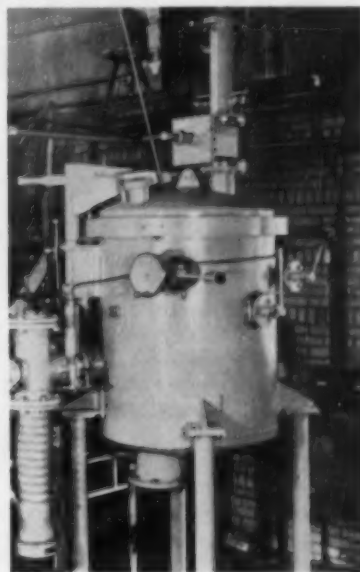
in a variety of thermocouple materials in several gages and outside diameters and in different types of seamless metal tubing. The thermo-

couple wires are made in lengths up to 30 ft. and the extension wires in varying lengths up to 2000 ft., depending upon the type of metal tubing and outside diameter. Extensions or thermocouples made of Ceramo wires will fit into openings that are too small for most ordinary wires. Furthermore, they can be formed easily to any configuration without short-circuiting.

For further information circle No. 649 on literature request card, p. 36-B.

Vacuum Furnace

A new 30 lb. induction-heated vacuum furnace has been announced by Naresco Equipment Corp. Available with either a vertical or horizontal shell, it is a completely self-contained



furnace for research and development purposes. Among its features are a co-axial power feed-through and means for adding additional charge material or alloying material during melting without losing the vacuum.

For further information circle No. 650 on literature request card, p. 36-B.

Vinyl-on-Metal Laminate

A new vinyl-on-metal laminate material which combines the corrosion resistance of vinyl plastic with the formability of metal is being made in coil form by Enamelstrip Corp. The new laminate can be deep drawn, sheared, crimped, bent, embossed, drilled, roll formed and punched, using standard tools, without damage to the coating or bond. It remains dimensionally stable up to 250° F. and will not support combustion. It will take more than 40 psi. in lap-off tests.

For further information circle No. 651 on literature request card, p. 36-B.

Tempilstiks®

*The amazing
Crayons
that tell
temperatures*



A simple method of controlling temperatures in:

- WELDING
- FLAME-CUTTING
- TEMPERING
- FORGING
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113	263	400	950	1500
125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000

FREE —Tempil® "Basic Guide to Ferrous Metallurgy" — 16 1/2" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

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MACHINING ACCURACY of gears, pinions, and shafts is maintained, and distortion minimized, by rapid mass marquenching after carburizing, in this Allcase furnace equipped with extra large quench tank and twin LIGHTNIN Mixers.



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667. Abrasive Wheels

Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

668. Air-Gas Mixer

Bulletin L-700 gives engineering and application data on air-gas proportional mixer. *Eclipse Fuel Eng'g*

669. Alloy Chart

Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications. *Cannon-Muskegon*

670. Alloy Specifications

Charts of chemistry, properties, specification designations of copper and aluminum alloys and babbitts. *Lavin*

671. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

672. Aluminum Alloy

Bulletin 103 on high strength aluminum alloy which ages at room temperature. *Federated Metals Div.*

673. Aluminum Alloys

62-page catalog gives standard aluminum products and new alloy designation system. Tables of chemical compositions, sheet bending. *Adam Metal Supply*

674. Aluminum Bronze

Folder on the vacuum die casting process and castings made by it. *Aurora Metal*

675. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

676. Aluminum Extrusions

28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

677. Aluminum Melting

Folder on electric furnaces for the aluminum alloy foundry. *Ajax Engineering*

678. Aluminum Strip

20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

679. Annealing Titanium

Data on annealing titanium parts in high vacuum furnace. *High Vacuum Equipment Corp.*

680. Arc Welding

New 16-page catalog on equipment and accessories for tungsten arc welding process. *Air Reduction Sales Co.*

681. Atmosphere Furnace

Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

682. Atmosphere Furnace

12-page bulletin on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

683. Atmospheres

Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell*

684. Atmospheres

Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

685. Barrel Finishing

12-page booklet on techniques and products. How it works, parts that can be barrel finished and operations the method performs. *Minnesota Mining and Mfg. Co.*

686. Basic Materials

24-page booklet on Alundum, Crystolon, Magnorite, Norbide, zirconia, carbides, borides and other basic materials. Products made from them are listed. *Norton*

687. Bearings

27-page bulletin, S-53, on self-lubricating bronze bearings, core and bar stock. *Amplex Division*

688. Beryllium

20-page booklet describes beryllium products, including the pure metal, oxide and alloys. *Beryllium Corp.*

689. Black Oxide Coatings

8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

690. Brass Bearings

New 24-page catalog on 600 series bearing alloys. Description of alloys, typical parts, properties, machining. *Mueller Brass*

691. Braze Tubing

12-page data book on brazed tubing made from copper coated steel. *Bundy*

692. Brazing

Discussion of brazing of SAE-1010 bicycle forks in a mechanized salt bath furnace. *Ajax Electric*

693. Brazing Alloys

Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

694. Brinell Machine

Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

695. Burners

Bulletin gives operation, applications, dimensions, output of oil burners. *Thermal Research & Engineering Corp.*

696. Carbides

4-page folder on die grades of cemented carbides for drawing, blanking, forming, heading, notching, piercing, punching. *Kennametal*

697. Carbon Brick

Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

698. Carbon Control

Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

699. Carbon Dioxide

Booklet gives uses of carbon dioxide in industry. *Liquid Carbonic Corp.*

700. Carbonitriding

28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

701. Carburizing

Bulletin on carburizers for pack carburizing. *Park Chemical*

702. Carburizing

16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

703. Casting, Precision

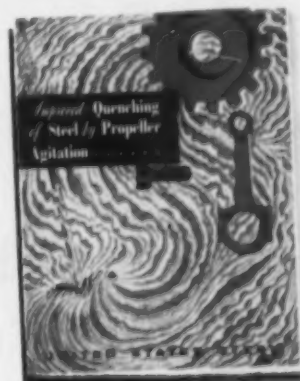
12-page book on alloy selection and design for precision casting. *Arnold Precision Casting Corp.*

704. Castings

New 16-page booklet, "Cast to Outlast Destructive Service", gives latest information and case histories on use of sand,

666. Quenching

"Improved Quenching of Steel by Propeller Agitation" is an attractive 24-page book containing tabular and graphic data on power requirements for propeller agitation and effectiveness of agitated quench baths in addition to the more general discussion of method of heat



transfer and means of quenching. One section of the book deals with the engineering of propeller agitation installations and takes up positioning and number of agitators in cylindrical and rectangular tanks. Typical examples using from 1 to 26 propellers in various positions for different quenching problems are discussed and illustrated. *U. S. Steel*

centrifugal and precision investment castings. *International Nickel Co.*

705. Castings, Bronze

16-page booklet on sand and centrifugal castings. *American Non-Gran Bronze*

706. Cemented Carbides

New 20-page catalog of complete line of cemented carbide blanks. *Firth-Loach Metals, Inc.*

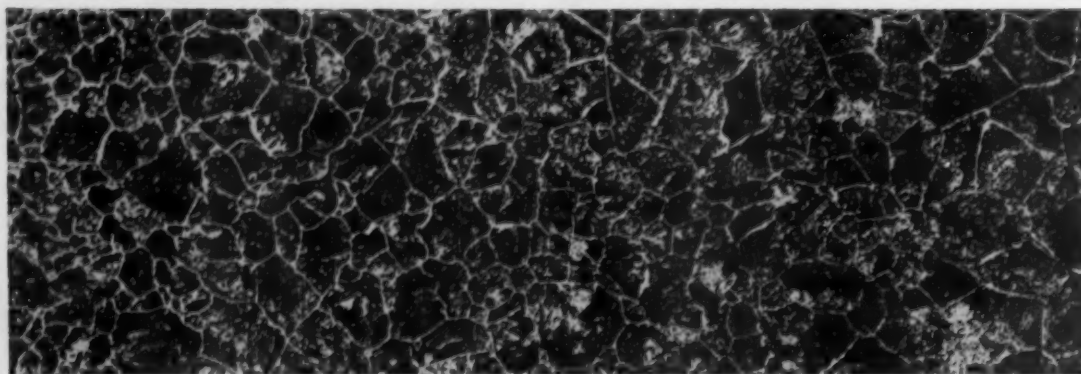
707. Cemented Carbides

24-page catalog on selection of cemented carbide grades and cutting speeds for various steels, nickel, copper alloys. *Carbology Dept., General Electric*

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File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

709. Chromium Plating

Booklets on how to chromium plate and anodes for the process. *United Chromium*

710. Cleaner

Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

711. Cleaners

Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

712. Cleaning

Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

713. Cleaning

Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

714. Cleaning

28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

715. Cold Rolled Steels

32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

716. Cold Treatment

Bulletin on sub-Arctic industrial cabinets for metal treating and research and production testing. *Tenney Eng.*

717. Colored Coil

Folder on aluminum, steel or other metallic coil finished in permanent colors. *Southern States Iron Roofing Co.*

718. Combustion Control

20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

719. Copper Alloys

64-page book on free-cutting brass, copper and bronze. *Chase Brass*

720. Copper Alloys

New 48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

721. Corrosion Resistance

Data sheet compares corrosion properties of Elgiloy and stainless steel. *Elgin National Watch Co.*

722. Cutting Oil Chart

Selection chart for seven classes of metal in nine machining operations. *Aldridge Industrial Oils*

723. Deburring

Catalog of tools for burr removing and chamfering of drilled holes, inside tubing, ends of rods. *Nobur Mfg. Co.*

724. Degreasing

34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

725. Descaling

Bulletin on new machines for descaling steel sheets, plates and coils after hot rolling or heat treating. *Pengborn Corp.*

726. Descaling Stainless Steel

Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

727. Dew Point Control

Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

728. Die-Casting Machines

Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

729. Die Sets

New catalog shows complete line of ball bearing die sets. *Lempco Products*

730. Electric Arc Furnace

Carbon and Graphite News contains an article on the electric arc furnace, an appraisal for management. *National Carbon*

731. Electric Furnaces

Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

732. Electric Furnaces

New bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

733. Electric Furnaces

Bulletin 441 on box-type electric furnaces diagrams and describes the furnaces and lists specifications. *Hevi Duty Electric Co.*

734. Electrode Control

4-page bulletin 162 on system of hydraulically positioning arc furnace electrodes. *Askania Regulator*

735. Extrusion Presses

8-page bulletin on aluminum extrusion presses describes the process and presses at work. *Watson-Stillman*

736. Filler Metal

New colored chart gives complete line of filler metals for welding, metal each is suited to, forms available and methods with which it is used. *Arcos Corp.*

737. Finishing

52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

738. Finishing Barrels

12-page catalog of horizontal and tilting tumbling barrels. *Globe Stamping Div.*

739. Flow Meters

Bulletin 201 on flow meter for gas used in heat treating. *Waukesa Eng'g*

740. Forgings

20-page booklet on forgings. Sections on nomenclature, design layout, die design and tolerance tables. *Consolidated Industries, Inc.*

741. Forgings

94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

742. Forgings

Catalog on forgings from copper, copper alloys and aluminum alloys. Compositions of alloys, properties, electrical conductivity, tolerances and specification numbers. *Scovill Mfg., Forgings Div.*

743. Forgings

Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

744. Freezer

Data on chest for use down to -95° F. for production use and testing. *Reeco*

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The turning of a single hydraulic control knob clamps the specimen, tests it, then releases it. The test is made in plain view, and the maximum pressure indicators show the result until reset. This highly sensitive sheet metal tester will take up to $\frac{3}{16}$ " thick specimens and exert up to 30,000 pounds pressure, at any desired rate of speed. Hydraulic mechanism is all neatly enclosed. Write for catalog sheet and prices.

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Van de Graaff®
Model JR offers

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Whether your inspection problems include

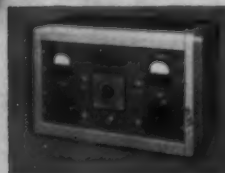
- ▶ high-quality production radiography of ½-inch to 5-inch steel sections
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The model JR is the answer

- ▶ with its constant-potential one-million-volt radiation, by means of its 1-mm x-ray focal spot
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Low cost — \$25,000 for x-ray generator, complete controls, and supervision of installation (less mount).

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See this new unit
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The Model JR can be supplied in a battery operated lift-truck mounting for positioning within the x-ray area without an overhead crane.

Complete lift-truck-mounted model — \$29,600.

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745. Furnace

Bulletin on Karbo-matic furnace for carbonitriding, dry cyaniding or automatic hardening. *Pacific Scientific*

746. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

747. Furnace Charging

12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

748. Furnace Construction

New catalog on suspended walls and arches for industrial furnaces. *Bigelow-Liptak Corp.*

749. Furnace Controls

22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

750. Furnace Fixtures

16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

751. Furnaces

40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

752. Furnaces

Folder describes complete set up for heat treatment of small tools, including draw furnace quench tank and high temperature furnace. *Waltz Furnace*

753. Furnaces

12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

754. Furnaces

Bulletin on specially designed continuous production furnaces for brazing, sintering, heat treating, melting, forging, etc. *Harper Electric Furnace*

755. Furnaces

6-page folder on gas-fired, oil-fired and electric furnaces. Typical installations. *Electric Furnace*

756. Furnaces

High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

757. Furnaces

Series of bulletins on controlled atmosphere, carburizing, nitriding, hardening furnaces. *American Gas Furnace*

758. Furnaces

Data on electric furnaces of top or side loading types. *Lucifer Furnaces*

759. Furnaces

8-page bulletin on continuous, car-type, reverberatory, recirculating and other furnaces. *Demsey Industrial Furnace*

760. Furnaces, Heat Treating

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

761. Gages

Data sheets on vacuum gages, direct reading, continuous measurement, control circuits. *Consolidated Vacuum*

762. Gas Analysis

New Bulletin No. 306 on gas analysis kits for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other gas mixtures. *Burrell*

763. Gas Analysis

Data on gas purity and trace impurity analyzer. *Gono-Mac Instrument Co.*

764. Globar Furnaces

Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

765. Gold Plating

Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. *Uses. Technic, Inc.*

766. Graphite

New 20-page brochure on significance of graphite as electrodes, anodes, molds and specialties in electrometallurgy and electrochemistry. *Great Lakes Carbon*

767. Grinding Magnesium

Data on how to grind and polish magnesium alloys includes grinding wheel recommendations, procedures, dust collection and safety precautions. *Norton*

768. Handling Devices

Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

769. Hard Surfacing

New 16-page book on "Electrolizing" tells what the process is, how it can be used, and advantages. *Electrolizing Corp.*

770. Hardness Numbers

Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

771. Hardness Tester

20-page bulletin on use of portable hardness testers and accessories. *Ames Precision Machine*

772. Hardness Tester

20-page book on hardness testing by Rockwell method. *Clark Instrument*

773. Hardness Tester

New 4-page folder on portable Brinell hardness tester which can be used in any position. Details of machine and its operation. *Andrew King*

774. Hardness Tester

Bulletin on hardness tester for all regular and superficial Rockwell tests. *Kent Cliff Div., Torsion Balance Co.*

775. Hardness Testers

Bulletin No. A-12 on new Wolpert-Gries machine for making Rockwell hardness tests. *Gries Industries*

776. Heat Processing

Bulletin answers questions: what is to be heated, what sections are to be heated, why the material is to be heated, to what temperature and for how long. *Selas*

777. Heat Resistant Alloy

10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

778. Heat Treating

Data on how to heat, quench, wash and temper automatically. *Metalwash Machinery*

779. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

780. Heat Treating Baskets

12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

781. Heat Treating Equipment

New folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

782. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*



Photo and data courtesy of The International Nickel Co., Inc.

Cost Slashed 84%

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This small latch cam for retrievable gas lift valves previously was machined from bar stock. The cost of machining the part in the hard metal required by oil well service was way out of line. So they had the cam Investment cast—and cut costs 84%.

Though this saving is unusually high, this modern casting technique can save you up to 60% on small parts production. It may also make possible designs you previously thought impractical to produce.

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This free 12-page booklet —"MODERN PRECISION INVESTMENT CASTING"—contains detailed data on the investment casting process.



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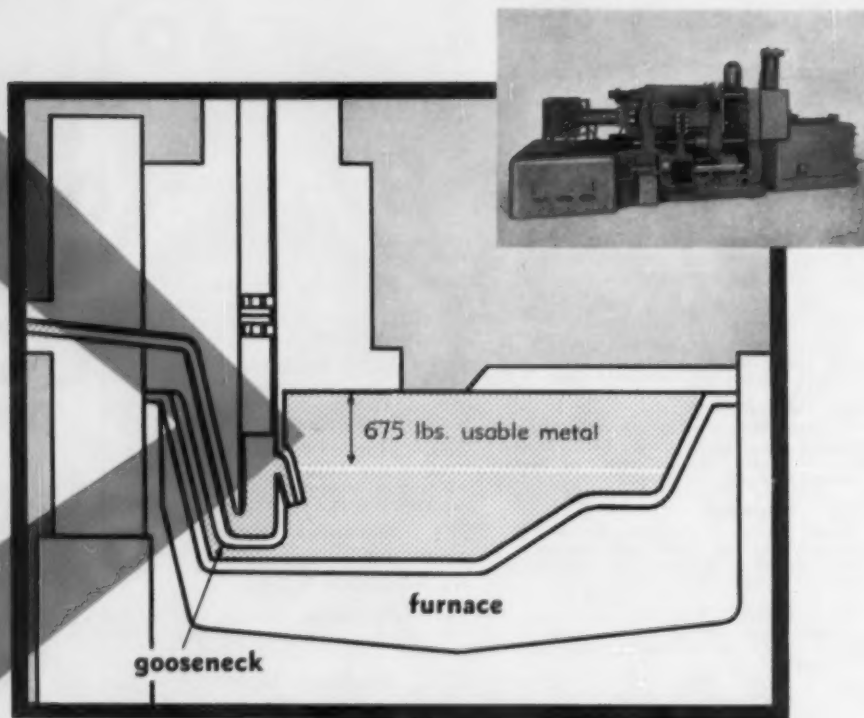
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DIE CASTING MACHINES

**675 lbs.
usable
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NEW gooseneck & furnace arrangement
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Re-designed Gooseneck and Furnace increase melting pot capacity to 1700 lbs. of zinc on the REED-PRENTICE #2 die caster; to 1150 lbs. of zinc on the #1 1/2 model.

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783. Heating

New booklet compares induction and dielectric high frequency heating. *New Rochelle Tool Corp.*

784. Heating Elements

24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

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Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

786. High-Temperature Alloys

"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 superalloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

787. High-Temperature Belts

New bulletin on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys Div.*

788. High-Temperature Belts

24-page bulletin on metal conveyor belts. *Wickwire Spencer.*

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36-page Catalog 750 gives formulas, constants, conversions used in vacuum work, pump selection data. *Stokes*

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24-page book "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U.S. Ind. Chem.*

791. Hydrogen Atmosphere

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792. Induction Heating

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793. Induction Heating

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794. Induction Heating

New 12-page bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

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796. Laboratory Furnaces

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799. Lead Steel

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801. Low-Carbon Stainless

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817. Mold Heating

Discussion of heating molds for "Lost Wax" investment castings in Heat Treat Review, Vol. 5, No. 1. *Surface Combustion*

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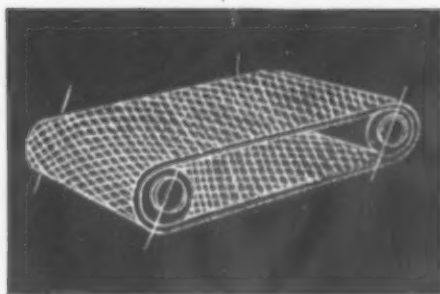
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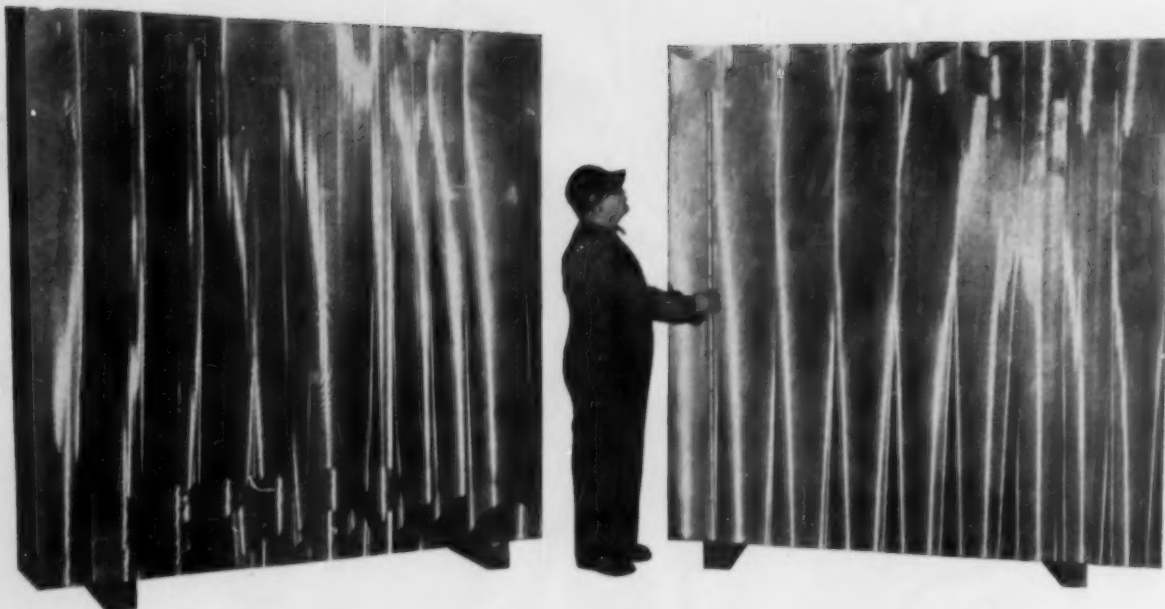
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From steel making, where quality of material begins, through forging, heat treating, rough and finished machining, and metallurgical testing where quality of workmanship counts, Finkl standards are the highest. For 76 years we have proved that the best is the least costly in the long run. Next time you are considering die blocks or forgings choose Finkl and you will choose the finest.

Call your nearest Finkl representative


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Western Warehouse LOS ANGELES 29: Finkl Steel Products Corp., 10735 Sessler Ave., LOrain 6-2134
Eastern Warehouse EAST CAMBRIDGE 41: Industrial Steels, Inc., 250 Bent Street, ELliot 4-7650

A. Finkl & Sons Co.

2011 SOUTHPORT AVE • TEL. DIVERSEY 8-2600 • CHICAGO 14

FORGINGS • DIE BLOCKS • ELECTRIC FURNACE STEELS



Where abrasion resistance is demanded...

Latrobe's **BR-4* FM** *does a better job!*

BR-4 FM conveyor belt
plates last 6 times longer at
CATERPILLAR TRACTOR CO.

At Caterpillar Tractor Co., regular mild steel plates (approx. $\frac{1}{4}$ " x 2" x 4") were formerly used on the conveyor carrying track link forgings through the induction hardening machine. These plates, subject to continual abrasion, only lasted 40 to 100 days, after which they were replaced.

Since using hardened BR-4 FM plates, no replacements, due to wear, have been required in over a year. Machine maintenance costs have been greatly reduced... another example of the economy possible when you select Latrobe's BR-4 FM die steel for special wear resistant applications.

Photo courtesy of
Caterpillar Tractor Co.



One of Latrobe's "free-machining" high alloy die steels, BR-4 FM was developed especially for applications involving extreme abrasive wear such as brick mold liners, shaving dies, stamping dies and deep drawing dies. As the result of the "DESEGATIZED" process, this high vanadium—high chromium die steel is uniform throughout thereby assuring equally high abrasion resistance on all surfaces, freedom from distortion and greater ease of heat-treating. Why don't you specify BR-4 on your next abrasion resistant application?

Call your nearest Latrobe representative for
complete details—Branch offices located in
principal cities.

Latrobe
STEEL COMPANY
LATROBE, PENNSYLVANIA

*Alloy Patented—U. S. Pat. No. 2575218



CLEANING SPECIALISTS

give you a "brighter" outlook on life.

It's amazing how pleasant the view can be after one of these steel-nerved, sure-footed, alert Cleaning Specialists have done their job.

Northwest's Metal Cleaning Specialists are "alert" to your problems when it comes to giving your products a "brighter" outlook. Day in—day out, Northwest carries on the constant search for better, lower cost, analytically-correct cleaners to give you dependable, good looking, permanent finishes.

From Northwest's years of experience in developing job-adjusted cleaners for your specific needs have come such processes as the LO-HI pH—for cleaning prior to plating, painting or vitreous enameling; ALKALUME—for preparing aluminum for finishing and spot welding; INTERLOX—for phosphate coating; SPRA-LUBE—to control over-spray of "today's" paints in water wash paint booths; PAINT STRIPPERS—specific to your needs; SUPER-DRAW & FLUID FILM—for drawing metals.

Northwest's production-tested chemicals and "Right-the-first-time" recommendations will save you money. Northwest Service is as close as your phone.

Remember —YOUR
COST PER FINISHED
ARTICLE IS THE TRUE
COST OF YOUR CLEANER



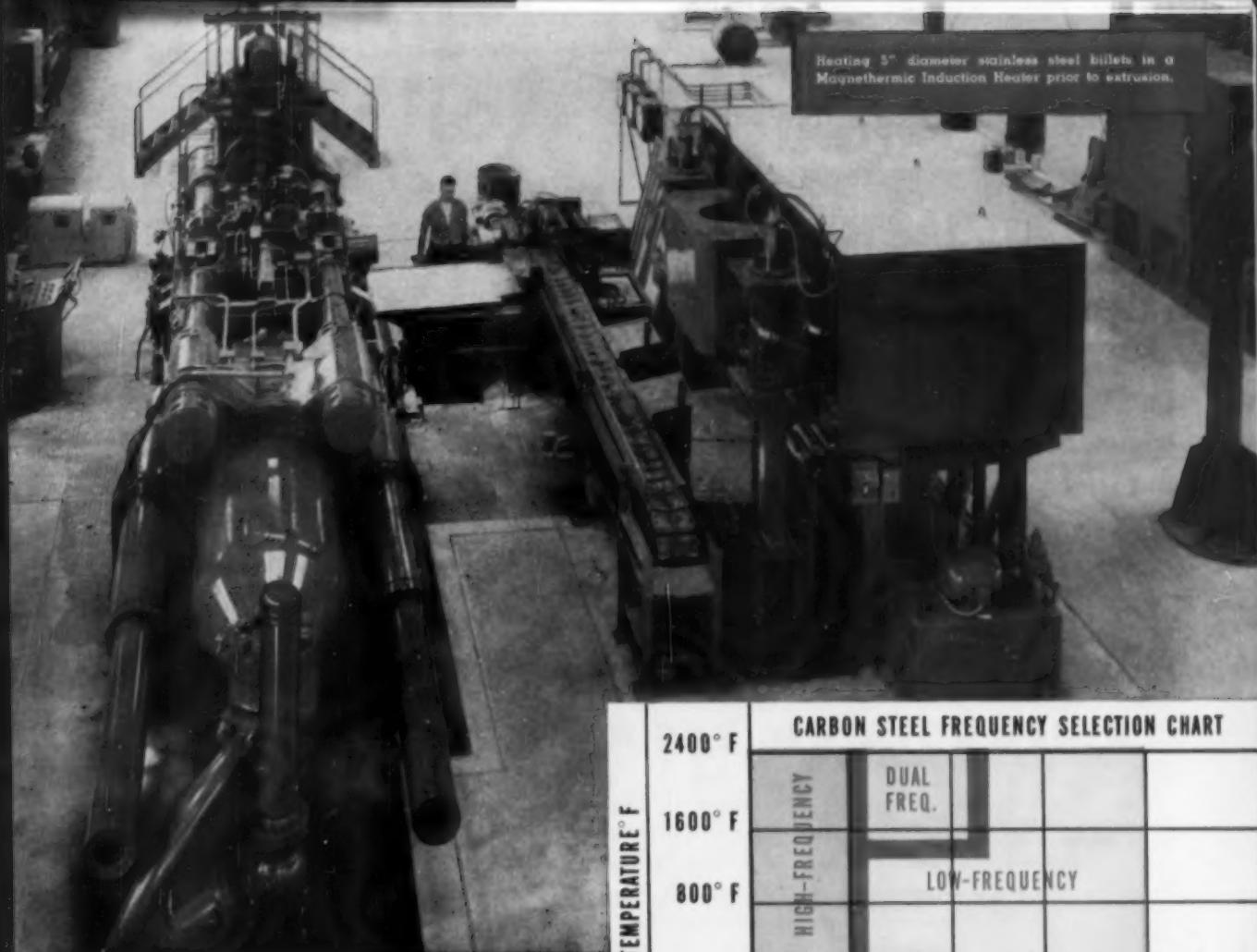
NORTHWEST CHEMICAL CO.

9310 ROSELAWN

DETROIT 4, MICH.

pioneers in pH cleaning control serving you since '32





Heating 5" diameter stainless steel billets in a Magnethermic Induction Heater prior to extrusion.

		CARBON STEEL FREQUENCY SELECTION CHART			
TEMPERATURE °F	2400° F				
	1600° F	HIGH-FREQUENCY	DUAL FREQ.		
	800° F		LOW-FREQUENCY		
		2"	4"	6"	8"
		DIAMETER OF BAR			

FORGE WITH INDUCTION HEATING

AND DO A BETTER JOB

With induction heat, a 5" diameter steel billet reaches forging temperature in less than five minutes. This rapid heating cuts operating costs by minimizing scale loss, maintenance costs, manpower and floor space. The equipment can be fitted into an automatic processing line, making billet pre-heating just one minor step in a forging operation. This is why modern production forging and extrusion plants are buying induction heating equipment.

Regardless of size of work or frequency, Magnethermic builds the equipment to meet your need. This company specializes in Induc-

tion Heating equipment, low-frequency or high-frequency, through 10,000 cycles. Write to Magnethermic for bulletin or information about your specific questions.

60 THROUGH 10,000 CYCLES

INDUCTION HEATING

MAGNETHERMIC
corporation

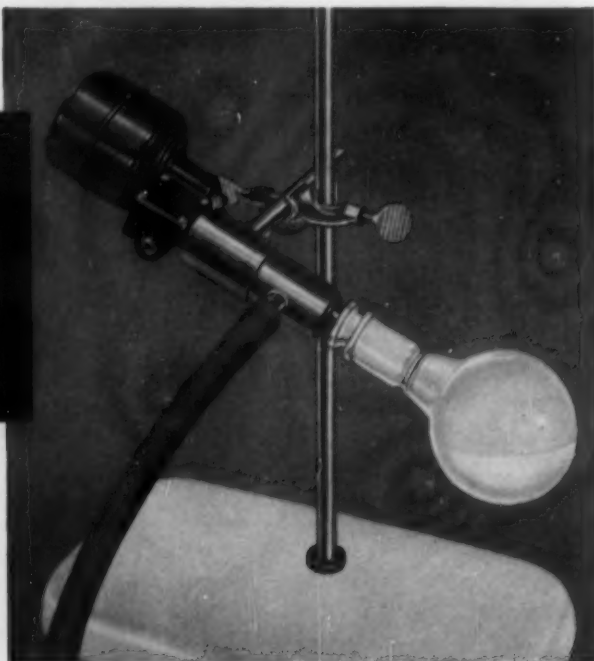
3990 SIMON ROAD YOUNGSTOWN 7, OHIO

60 THROUGH 10,000 CYCLES

**for rapid
evaporation
of solvents of
low volatility**

USE

THE



RINCO ROTATING VACUUM-TYPE EVAPORATOR

(Patent Applied For)

● For speeding up routine evaporations. Handles volumes from 1 c.c. to 1000 c.c. Principle utilized—rotation of flask spreads out thin film over large area (diameter of flask) subjected to negative pressure. "Bumping" eliminated. Use of glass beads unnecessary. Rate of evaporation increased 4 to 5 times, depending on solvent used. Particularly advantageous with such solvents as water, dimethylformamide, etc. 30 ml. of water at 20° C will be evaporated in 30 minutes or less. Very useful with heat sensitive compounds and biological extracts since no temperature increases are necessary. Evaporator will, of course, operate satisfactorily at higher evaporation rates with increased temperature, when sample characteristics permit application of heat.

Evaporator consists essentially of a stainless steel shaft with a machined Standard Taper 19/38 joint at lower end. Shaft rotates on oilite bronze bearings within stainless steel housing having Standard Taper 12/30 take-off leading to vacuum pump or aspirator. Vacuum pump and trap are recommended for best results, but can be used with aspirator. Flask attached to Standard Taper joint at lower end of shaft rotates at approximately 60 r.p.m. by means of special motor. Standard Taper 19/38 joint accommodates smaller capacity flasks, i.e., 50 ml. H-63620 Reducing Adapters, Pyrex Brand Glass, permit use of larger flasks having Standard Taper 24/40, 29/42, etc. Entire apparatus can be easily disassembled for cleaning.

Note: Support stand, clamp and glassware are accessories and may be ordered separately.

Can be adapted to single or multiple units.

H-21655—Rinco Rotating Vacuum-type evaporator complete with motor and cord for use on 115V 60C, A.C. . . . **\$96.50**

HARSHAW SCIENTIFIC

DIVISION OF THE HARSHAW CHEMICAL CO.
CLEVELAND 6, OHIO

Cleveland 6, Ohio
1945 East 97th St.
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TO
Improve Quality

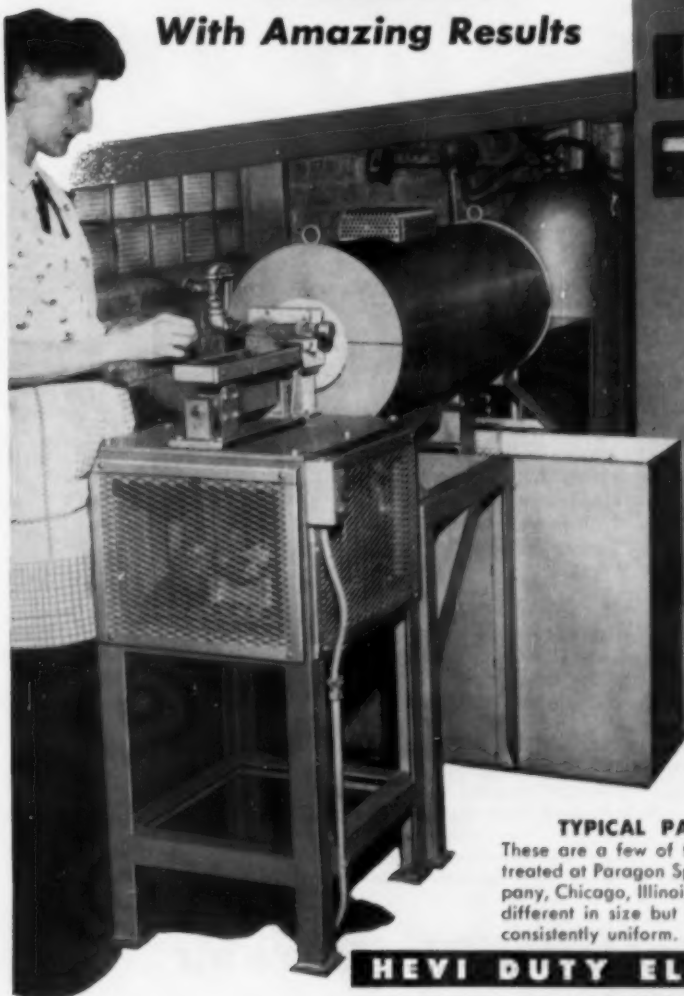
PARAGON SPRING CO.

USES A

HEVI DUTY

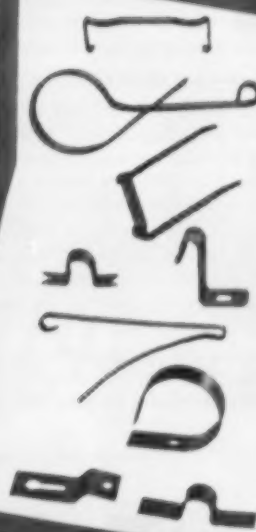
**SHAKER HEARTH
FURNACE**

With Amazing Results



TYPICAL PARTS

These are a few of the springs treated at Paragon Spring Company, Chicago, Illinois. They are different in size but results are consistently uniform.



HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators

Here's what Ed. Stanek says . . .

Ed. Stanek, Heat Treating Superintendent says, "We sure were amazed at the improved quality of our springs. With our new Hevi Duty Shaker Hearth Furnace, we get clean scale-free parts that do not require pickling or sandblasting before plating. In addition to that, we get a better, cleaner plating job than before. The parts retain their carbon and are less subject to hydrogen embrittlement. Now, heat treating takes less time and rejections have been practically eliminated. Our customers are really getting fine quality springs."

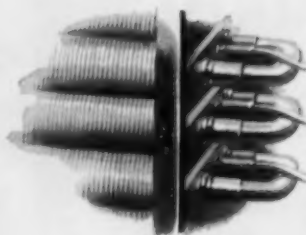
UNIFORM CASE DEPTH

This Hevi Duty Shaker Hearth Furnace is fully adjustable to give complete control of heat treating processes such as Hardening, Dry Cyaniding and Carburizing. Write for Bulletin HD-850 describing the furnace that assures uniform results on a production basis.

How STRAITS TIN from MALAYA is being used to make better products at lower cost



A new alloy designed for use as a heat transfer medium consists of tin, indium and lead.



Tin solder coatings on air-conditioning fin coils help prevent odor accumulation.



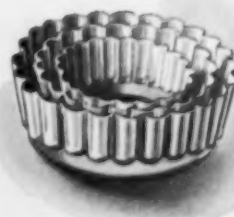
Millions of miles of copper wire are tinned to avert corrosion by rubber insulation.



New electrotin (tinned steel plate) is now widely used for air and oil filters in automobiles.



Car and airplane pistons of aluminum are often given a coating of tin as a lubricant.



Tin or copper-tin molds are used to give puddings and other desserts a decorative shape.

The number of new ways you can use Straits Tin to make better products at lower cost is today growing faster than ever. And lower cost means higher profit.

To cite just three examples—

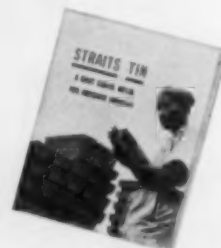
New turbo-prop engines in many aircraft have phosphor bronze bushings containing tin. The new chlorinated rubber paints have 5 to 10 times longer life with addition of organotin chemicals. And a new tin-rich tin-zinc-cerium solder for aluminum speeds solder application and has better resistance to salt spray corrosion.

Fortunately there is plenty of tin to meet this increasing list of new uses. Known reserves are adequate for the foreseeable future no matter what the needs of American industry may be.

Over one-third of the world's tin comes from the Federation of Malaya. This country, keystone of Southeast Asia, is steadily winning its war against Communist guerrillas. With increased security in this strategic area you can count on a supply of tin just as dependable as the supplies of other materials produced in the Free World.

Straits Tin from Malaya—at least 99.87% pure—is inert, nontoxic, friction and corrosion resistant. It is highly malleable, has a relatively low melting point (450°F.), and can be alloyed with most other metals.

Whatever you make, a long, careful look at the properties of Straits Tin may show you how to make it better—at lower cost.



A 20-page new booklet gives an informative report on Straits Tin and its many new uses today. Write for a free copy now.

Since February 1953, there have been no restrictions by the U.S. Government on the use of tin.

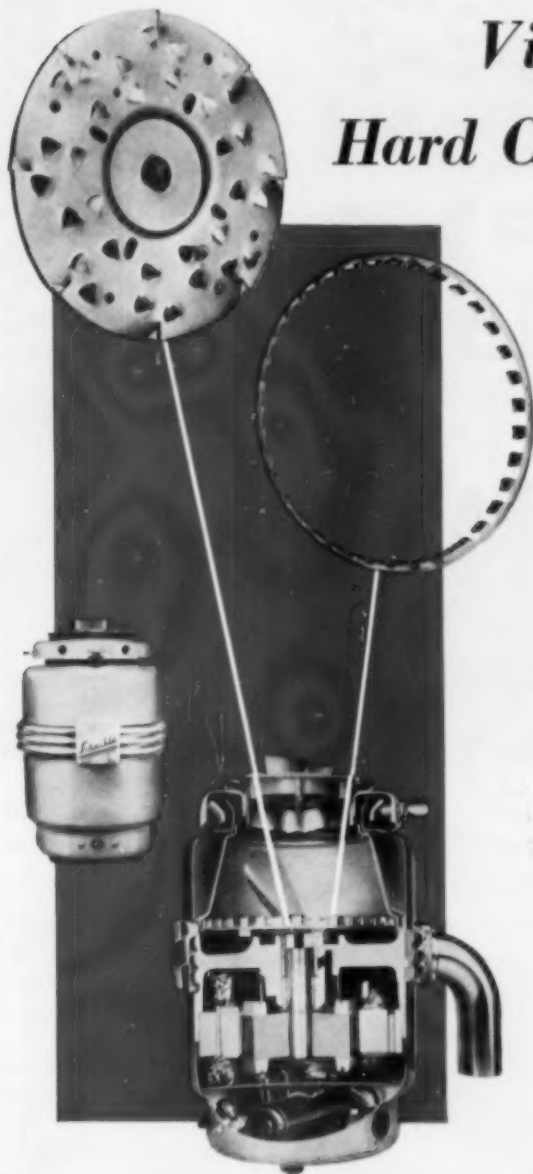


The Malayan Tin Bureau

Dept. CC-1, 1028 Connecticut Ave., Washington 6, D.C.

The Schaible Story:

Vital Grinder Parts Hard Cased in Park-Kase 5-C



The new grinding principle of the Schaible Food-Waste Disposer is shown here. Particle discharge size is positively controlled by reduction grating through horizontal milling action, impingement cutting and clipping. The snag-toothed cutter and the clip ring used in this process require hardness and toughness. Park-Kase 5-C gives these tools the necessary hard case for years of efficient, dependable service.

Fifth in a series of advertisements
describing Park processes on the job

Maximum Hardness at LESS COST for Schaible Cutter Disc and Clip Ring!

At the Schaible Company the grinding elements used in the production of the Schaible Food-Waste Disposer are precision hard cased with water soluble Park-Kase 5-C. Result: a higher hardness which means longer life and greater efficiency for these fast-action grinding teeth . . . *in less time and at less cost.* Here's why:

The rapid and uniform case depth of Park-Kase 5-C liquid carburizer means fast, reproducible cases which can be held to close limits for accurate, dependable work at temperatures up to 1700°F. Park-Kase 5-C produces eutectoid carbon cases which contain enough nitrogen to be file hard after oil quenching. High penetration rates and ease of cleaning are combined for ideal carburizing conditions. Inexpensive, simple, and trouble-free . . . Park-Kase 5-C lowers production costs.

- Lightness of Original Charge and Reduction of Salt Drag-out Keeps Costs Down.
- Does Not Foam While Operating.
- Water Solubility Means Time Saved on Oil Quenched Work.
- Needs No Special Complicated Mixing Procedures.

Complete details of the Park-Kase 5-C Carburizing process covering all phases of its operations are described in a technical bulletin available by mailing the attached coupon.

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement



PARK CHEMICAL CO.

8074 Military Avenue • Detroit 4, Michigan

Send Free Bulletin Describing Park-Kase 5-C

Name _____ Position _____

Company _____

Address _____

City _____ State _____



**“WOW! what happened
to our labor cost
on this run?”**

How many times—and how recently—have you asked this question? It's a good one, with a lot of possible answers. The important thing is, can these skyrocketing costs happen again, or have the causes been corrected? Often the answer is very simple—and easily remedied.

**Could this
be your
answer?**

A batch of castings or forgings with cracks that nobody found until costly hours had been wasted machining and finishing them . . . a heat treat that went sour . . . improper grinding, handling, cleaning, all are possibilities, and all can vary from run to run.

Cracks, whatever the cause, run up your labor costs if you don't find them *early* enough. Early enough to find

and correct the cause before parts are run and finished in quantity, only to be scrapped.

Inspection is low cost with Magnaflux' Methods and it finds all cracks...helps you find the cure. It can save you many times its trifling cost.

Ask to have a Magnaflux engineer give you facts and figures—or write for new booklet on **LOWER MANUFACTURING COST**.

MAGNAFLUX



MAGNAFLUX CORPORATION

7346 West Lawrence Avenue • Chicago 31, Illinois

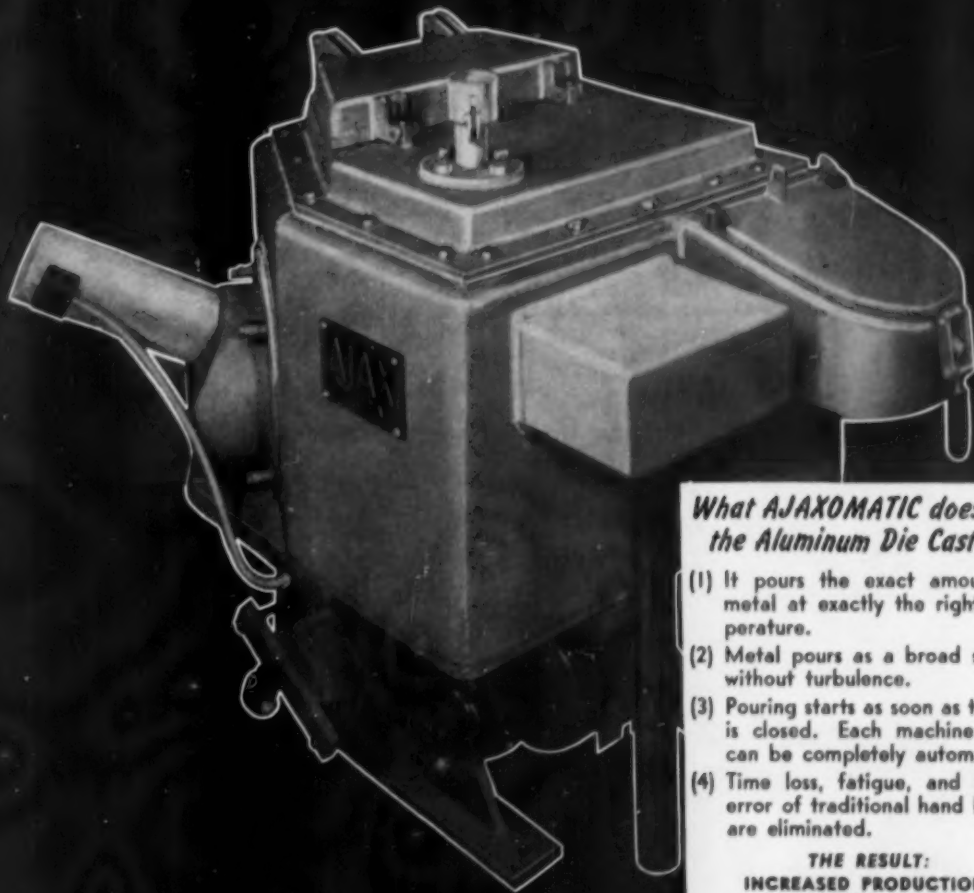
New York 36 • Pittsburgh 36 • Cleveland 15

Detroit 11 • Dallas 19 • Los Angeles 58

AJAXOMATIC



AN AUTOMATIC POURING UNIT FOR THE
PRODUCTION OF ALUMINUM DIE CASTINGS



*What AJAXOMATIC does for
the Aluminum Die Caster:*

- (1) It pours the exact amount of metal at exactly the right temperature.
- (2) Metal pours as a broad stream without turbulence.
- (3) Pouring starts as soon as the die is closed. Each machine cycle can be completely automatic.
- (4) Time loss, fatigue, and human error of traditional hand ladling are eliminated.

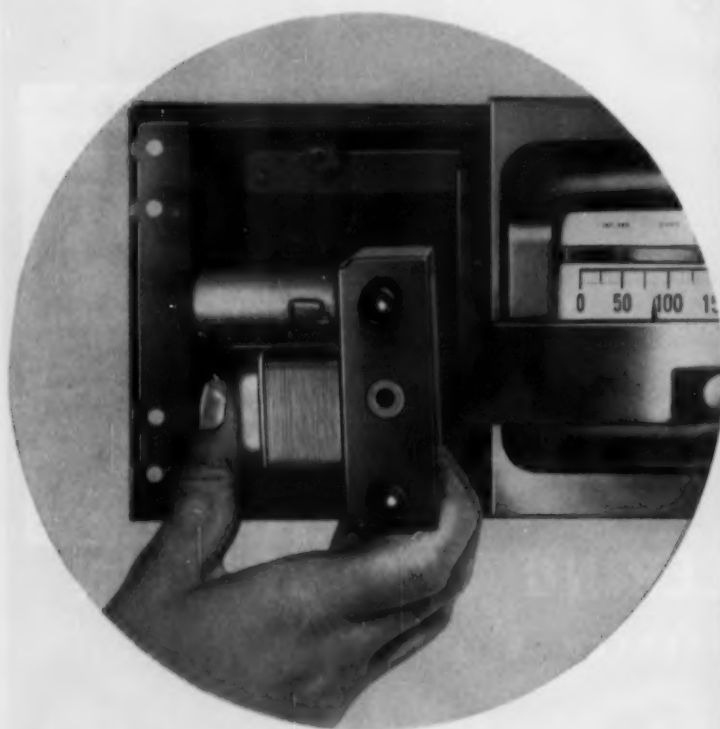
THE RESULT:
INCREASED PRODUCTION,
CONSISTENT QUALITY,
HAPPIER WORKERS.

AJAX ENGINEERING CORPORATION

TRENTON, N. J.

**Brand new in
performance...
versatility...
style...**

■ the horizontal case



- ***New versatility of control—choose from***
 - snap-acting on-off control
 - pulse-type time-proportioning control
 - three-zone control with dual indexes
- ***New ease of maintenance***
 - plug-in galvanometer and control units
 - thermocouple and millivoltmeter can be calibrated without disconnecting wiring
- ***New precision of measurement***
 - virtually unaffected by ambient temperatures from 50 to 110 F.
- ***New ease of mounting***
 - 19" wide case fits standard relay racks
- ***New convenience in operation***
 - signal lights on control unit show high and low control position



Pyr-O-Vane[®] Controller

THERE'S more than a new look to this new *Pyr-O-Vane* millivoltmeter temperature controller. Its advanced performance and added features of versatility make it, more than ever, your top choice for economical, dependable control of ovens, furnaces, driers and scores of other kinds of heating equipment.

Its 19-inch wide horizontal case fits standard relay racks . . . permits stacking of controllers in smart-looking central panels. Plug-in unitized sub-assemblies reduce spot maintenance to seconds. Just replace the operating unit with a standby . . . and control continues with practically no interruption.

New refinements give the *Pyr-O-Vane* Controller greater precision and broader flexibility of control than ever before. Its sensitive electronic control

can be applied to either fuel-fired or electrically-heated equipment. Your instrument men will appreciate its added ease of calibration and servicing . . . and your production men will like its dependability that stems from long-lasting, precision-made Brown components.

Whether you're modernizing your plant or modernizing the design of heat-using equipment that you manufacture, plan to take advantage of the new *Pyr-O-Vane* Controller . . . and its companion instrument, the new *Protect-O-Vane*[®] excess temperature safety cut-off. Your local Honeywell sales engineer will be glad to consult on your specific application . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO.,
Industrial Division, Wayne and Windrim Avenues,
Philadelphia 44, Pa.

● REFERENCE DATA: Write for new Bulletin 1060, "Horizontal Case Millivoltmeter Controllers."

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS



First in Controls

Another "must" for proper Metallographic Control

The **AB** MICROMET ETCHER

A self-contained variable d.c. power supply for electrolytic etching of prepared metallographic specimens.

This neat compact unit is always ready to operate eliminating time consuming hook ups and delays due to battery failure.

All controls are advantageously located for fingertip adjustment. Twin type voltmeter and ammeter are positioned for ready and easy observation.

Properly identified leads for the cathode and the anode with forceps for contacting or holding the specimen are supplied. A replaceable beaker and fitted cathode clip to support either the vertical or horizontal stainless steel cathode are furnished.



Buehler Ltd.

METALLURGICAL APPARATUS
2120 GREENWOOD STREET
EVANSTON, ILL., U.S.A.



**formula
for lowest
heat-hour
costs:**

**SPECIFY
DRIVER-HARRIS
ALLOYS**

**... follow
the maker's
operating
instructions**



Regardless of what alloy your heat-treating equipment is made of, it will pay you well to heed closely the manufacturer's operating instructions.

Many users of D-H alloy retorts, muffles, and liquid pots have heeded this advice—and the figures show the benefits they received.

1. They avoided thermal shock by heating the containers *slowly* to the recommended temperatures before starting work.

2. They did not let them go completely cold over week-ends or between work periods.

They realized that fine equipment is cheaper than fuel . . . that the added life of the containers is well worth the moderate expense of keeping them at correct idling temperatures when not in use.

This advice will serve you well—to repeat—no matter what alloy you are using. Of course, for the absolute maximum in long life . . . the lowest heat-hour costs . . . it would be well at the outset to specify Nichrome, Chromax, or Cimet, alloys with a consistent history of outstanding performance.



*Nichrome®, Chromax®, Cimet® are
manufactured only by*

Driver-Harris Company
HARRISON, NEW JERSEY

*T. M. Reg. U. S. Pat. Off.

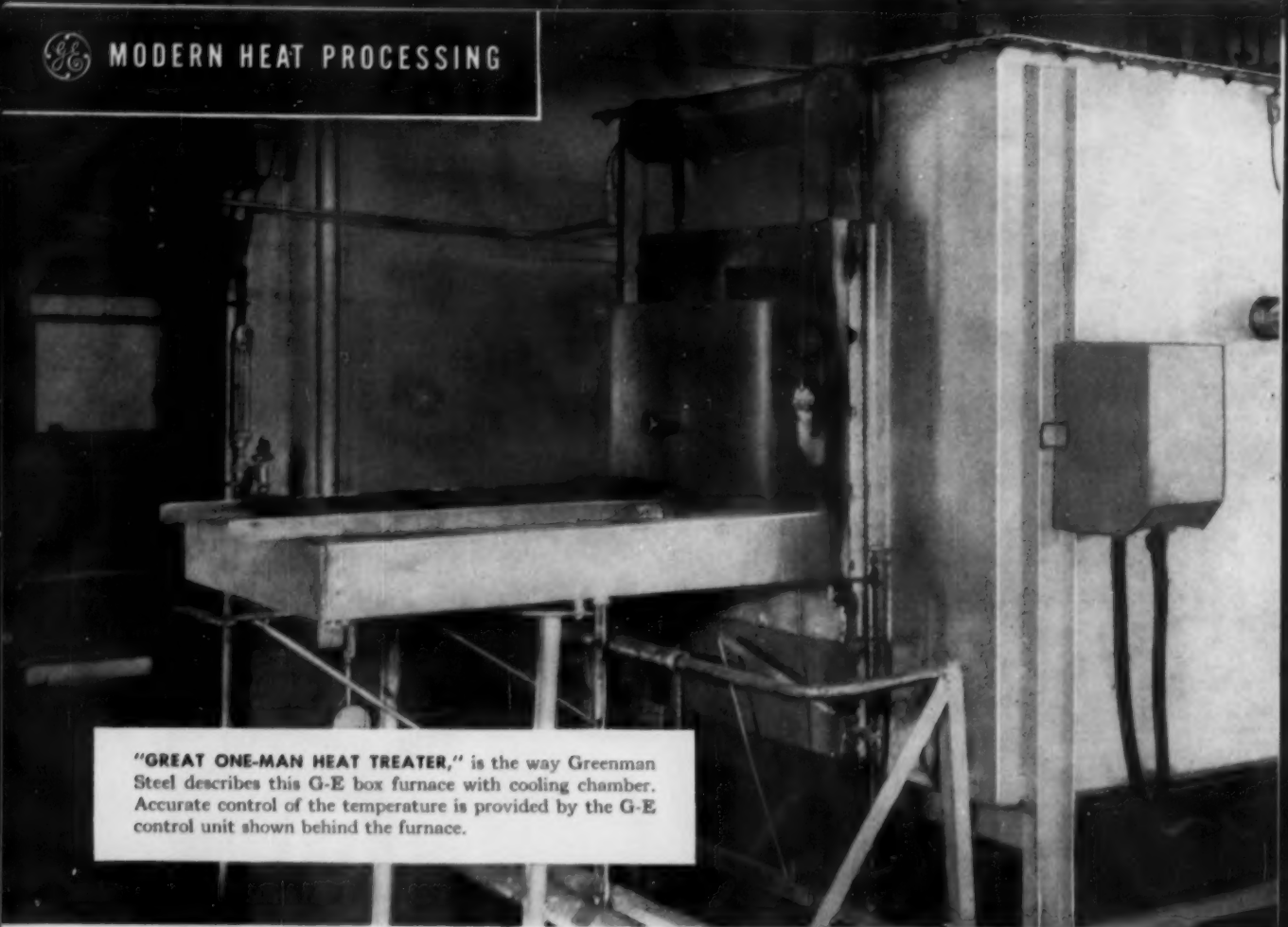
BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Louisville

MAKERS OF WORLD-FAMOUS NICHROME AND OVER 80 ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING FIELDS

MARCH 1955; PAGE 49

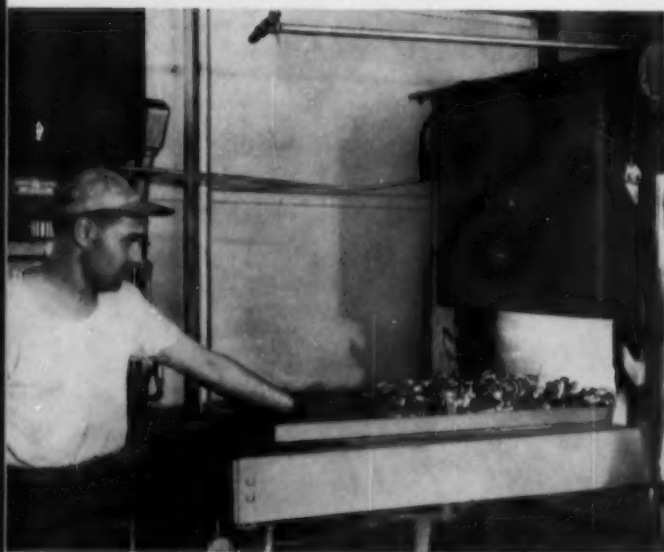


MODERN HEAT PROCESSING



"GREAT ONE-MAN HEAT TREATER," is the way Greenman Steel describes this G-E box furnace with cooling chamber. Accurate control of the temperature is provided by the G-E control unit shown behind the furnace.

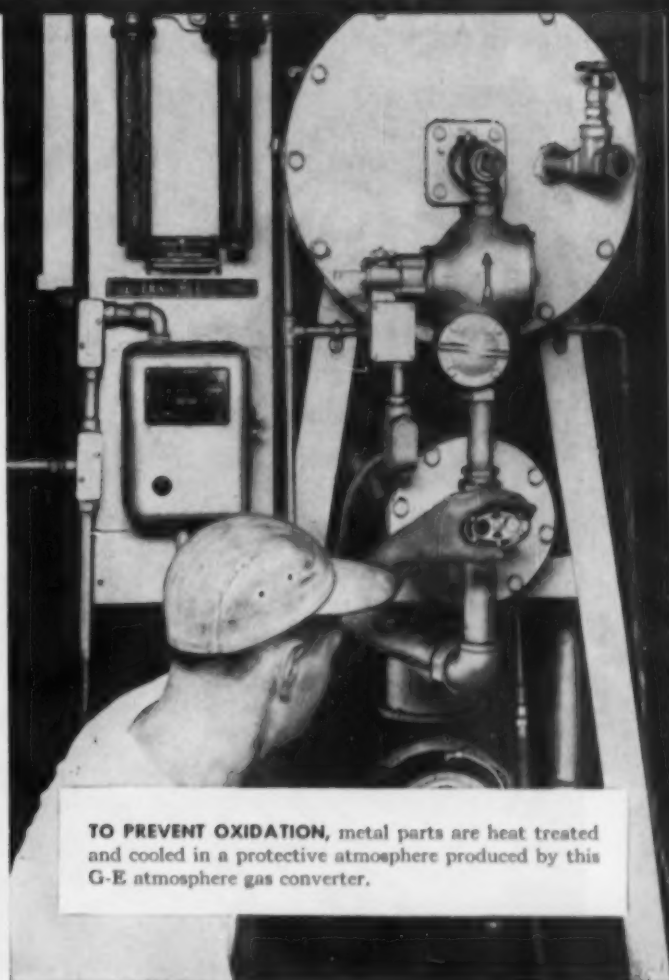
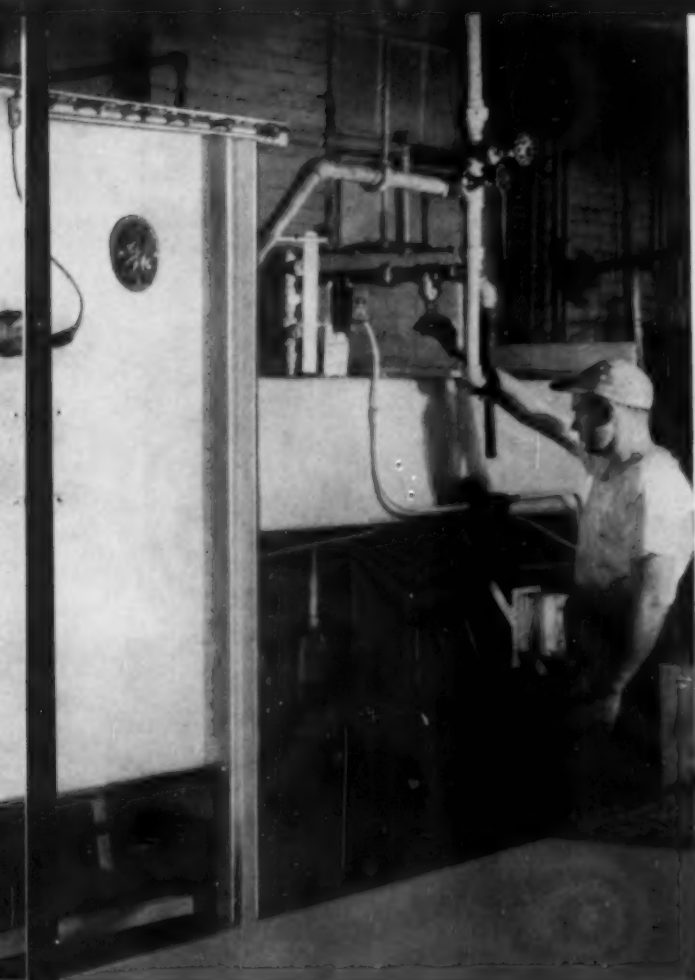
"Versatility of G-E Furnace Almost



MANY HEAT-TREATING JOBS can be done with this one G-E box furnace. Greenman Steel uses it for copper brazing, silver brazing, annealing, and hardening. Here, the furnace is employed to anneal drawn-steel cups.



HIGH-QUALITY WORK is achieved by moving the parts directly from the furnace to the atmosphere cooling chamber, thereby minimizing oxidation. Here, the parts emerge from the cooling chamber clean and bright.



TO PREVENT OXIDATION, metal parts are heat treated and cooled in a protective atmosphere produced by this G-E atmosphere gas converter.

Unlimited," Says Industrial Heat Treater

Operational savings of G-E furnace keep Greenman Steel competitive

Heat-treating jobbers who demand versatility in a furnace find that General Electric's box furnace with water-jacketed cooling chamber is ideal for general-purpose work.

Says Lloyd G. Field, General Manager of Greenman Steel Treating Corp., Worcester, Mass.:

"As a heat-treating jobber, we have to produce high-quality work at lower cost than equipment manufacturers can do it themselves. We must be ready to handle all sorts of heat-treating jobs, yet our investment in equipment must be kept to a minimum. We find that our G-E box furnace satisfies all these requirements. It enables us to stay competitive because it produces

superior work at low cost. It minimizes our equipment costs because its versatility is practically unlimited. We use it to copper braze, silver braze, anneal, and harden."

MANY SAVINGS, HIGH-QUALITY WORK

Mr. Field pointed out that operating costs are low because the insulating qualities of the furnace minimize heat loss. Automatic control of the heat assures him of high-quality work.

FOR APPLICATION HELP

Whether your operation demands a small-capacity, all-purpose furnace, or one that is engineered for a particular process and intended for high-production rates at the lowest possible cost, General Electric can satisfy your requirements. For application help from a G-E Heating Specialist, contact your G-E Apparatus Sales Office.

GENERAL  ELECTRIC

WRITE NOW FOR THESE MODERN HEAT PROCESSING BULLETINS

• Furnace and Induction Brazing, GEA-5889

• Annealing Malleable Iron, GEA-5797

• Forging with Induction Heat, GEA-5983

• Heat-treating Aluminum, GEA-5912

• Protective Atmosphere, GEA-5907

• Wire Enameling, GEA-6179

Address: General Electric Co., Section 720-129, Schenectady 5, N. Y.



GREATER STRENGTH AND LONGER SERVICE LIFE ... THANKS TO *GAS*

This is one heat treating operation at the Construction Equipment Division of the Baldwin-Lima-Hamilton works in Lima, Ohio. In the center of this battery of gas-fired burners is a shipper shaft pinion, soon to become a vital part of a Lima shovel.

The temperature is controlled at 1500°F. After a water quench and a gas-fired tempering process, the teeth and the teeth base of the pinion will have a uniform hardness up to two inches in depth. This means longer service life for this important part.

Gas-fired equipment is also used for flame hardening on rollers, gears, and shafts of every Lima machine. Cost conscious equipment men everywhere know that they can depend on Lima for low maintenance and less down-time. Gas equipment, operated by skilled technicians, helps give Lima this world-wide reputation.

Throughout industry, Gas is proving the most satisfactory method of heat processing. That's reason enough for discussing your problem with your Gas Company's industrial specialist. *American Gas Association.*

NATIONAL
CARBON
COMPANY'S

CARBON AND GRAPHITE NEWS



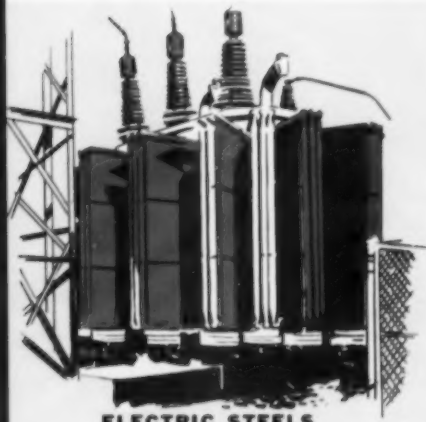
CARBON STEELS



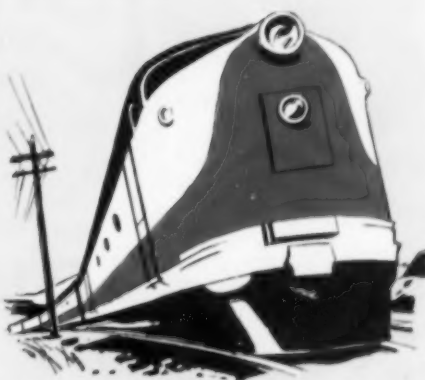
ELECTRIC ARC FURNACE



ALLOY STEELS



ELECTRIC STEELS

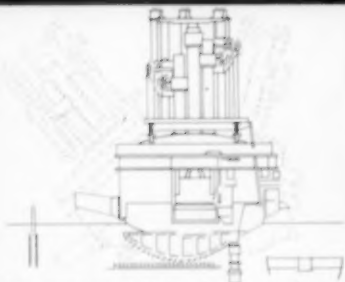


BEARING STEELS



STAINLESS STEELS

IN THIS ISSUE



"FLEXIBILITY" of the electric arc furnace — defined . . . analyzed . . . what it means to the steel producer — subject of our feature article by . . .



EDWARD A. HANFF, active since 1917 in design, development and application of arc furnaces—a recognized authority in steel producing and foundry industries.



PROPERLY made electrode joints stay tight with this new Pitch-Reservoir nipple, designed to prevent collar- and nipple-loss at the arc-end of furnace electrodes.

"An important advantage of electric furnace steelmaking lies in the greater flexibility of the arc furnace."

This statement is taken from the technical and economic study prepared by Battelle Memorial Institute* and published in July 1953. As comprehensive and complete as this study was, there are, of course, a number of factors of this kind which could not be fully discussed within the scope of Battelle's assignment.

In alignment with our expressed policy of dealing more completely and in more specific terms with various aspects of the electric furnace, our Guest Author has defined in some detail the term "flexibility" as applied to the electric furnace, and has "spelled out" its importance in steel making. The feature article, FLEXIBILITY OF THE ELECTRIC ARC FURNACE — WHAT IT MEANS TO THE STEEL PRODUCER, by E. A. Hanff, contains an accumulation of knowledge acquired from many years of association with the steel industry and experience in equipment building.

We are always glad to receive your comments on CARBON AND GRAPHITE NEWS. They enable us to keep this publication closely attuned to your interests.

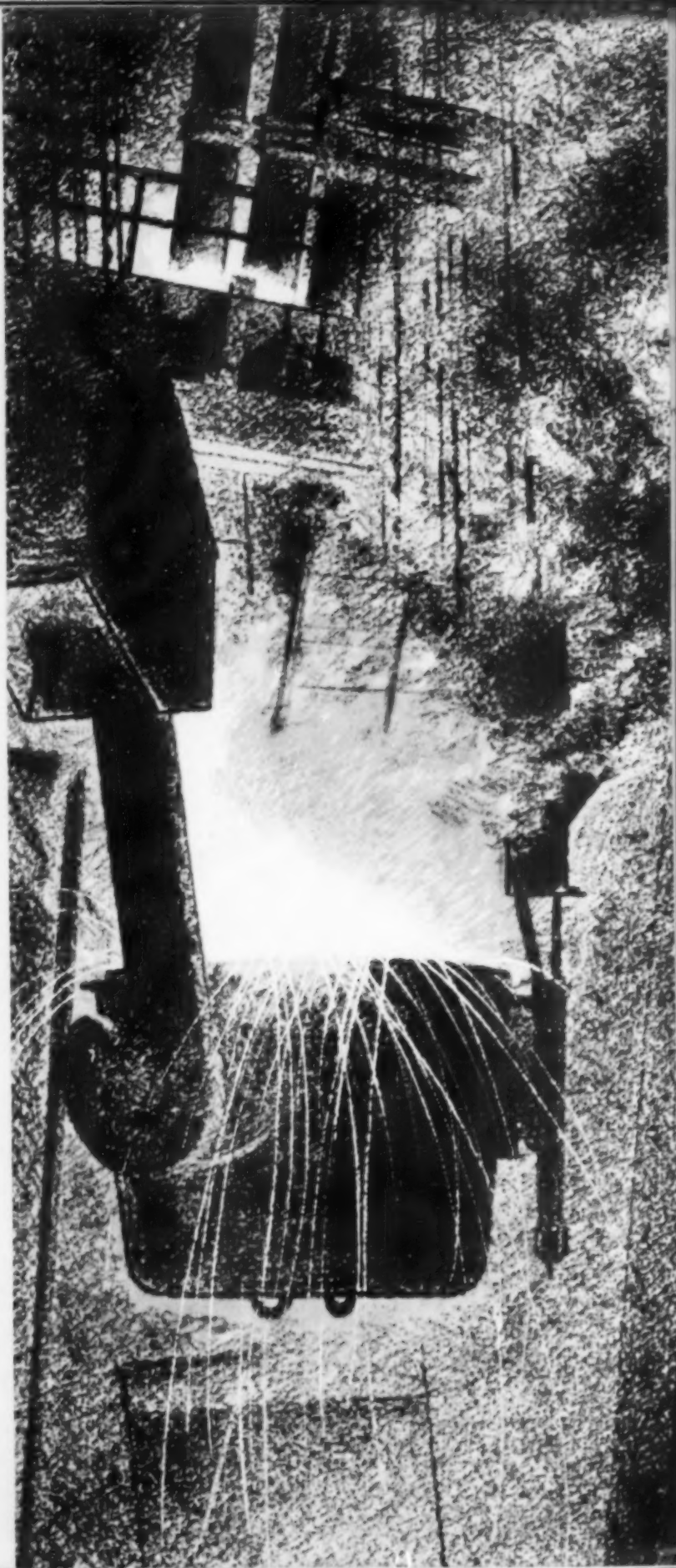
Al Johnson
PRESIDENT

**Comparative Economics of Open-Hearth and Electric Furnaces for Production of Low-Carbon Steel, a technical and economic study sponsored at Battelle Memorial Institute by Bituminous Coal Research, Inc., and fourteen electric utility companies.*

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FLEXIBILITY OF THE ELECTRIC ARC FURNACE— WHAT IT MEANS TO THE STEEL PRODUCER

By E. A. HANFF

DISCUSSIONS and analyses of the electric arc furnace invariably make some reference to its flexibility, but definitions of this attribute are lacking, possibly because it lends itself to many interpretations and can encompass practically every phase of electric furnace shop operation. This is in contrast to the more easily defined advantages of the electric furnace, such as: high thermal efficiency, close quality control, low capital investment, high rate of production, compactness, reduced down-time, low maintenance and labor cost, and so on.

What Is Flexibility

The dictionary defines FLEXIBILITY as *that which is responsive to, or readily adjustable to meet requirements; susceptible to modification or variation; manageable and adaptable.*

The purpose here is to examine, within the framework of this definition, the many ways in which flexibility of design and operation of the electric arc furnace satisfies the changing requirements of the steel industry.

Flexibility to Meet Changing Business Conditions

Of real interest and concern to steel producers today is the necessity to adapt their operations to meet changing market demands, changing work-week and work-day schedules and, at the same time, to avoid the adverse influence of varying availability and quality of raw material supplies and fuels. These are only some of the more obvious factors. The flexibility of the electric arc furnace meets these conditions in many ways.

The short melting and refining cycle of the arc

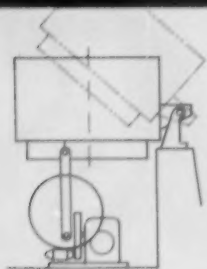
furnace lends itself to any practical shift and work-day schedule, with the ability to change, almost at a moment's notice, to a different schedule. Since long and costly preparations for starting up are unnecessary, one or all of the arc furnaces in the shop can be put on the line with a minimum of expense. No serious thought need be given to keeping the furnace hot between heats, as must be done with most other melting furnaces.

Flexibility in operation allows the shop to produce on three shifts or on only one shift, if desirable; or only during off-peak, low-cost electric current-load periods at an economic advantage. Large ingot production shops are thus in a position to shift over partially or entirely to custom production of practically any product analysis, in any quantity, and at any time.

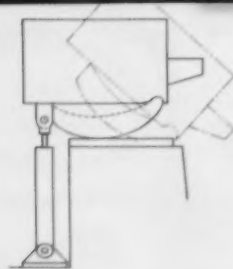
The average arc furnace can be overloaded to 130 per cent of normal capacity as normal practice, or it can tap a special heat of only 30 per cent of its rated charge and still be able to slag-off the undersized heat. There are instances of arc furnaces being overloaded as much as 100 per cent to meet critical demands. This is of particular importance in the production of special castings for which large melting equipment is not justified because of intermittent demand.

When competition is most acute, the buyer expects and demands quick delivery of product because he carries less inventory and is in a position to be critical of types and quality of material. Steel producers are in a good position to meet these conditions with the electric furnace by changing compositions, quantities and operating shifts at will and with economy.

(Continued on next page)



**Nose Tilt
Crank Operation**



**Bottom Rocker
Hydraulic Operation**

By virtue of its flexibility in size, needed electric furnace capacity can be installed in units or multiples of units from under two tons up to two hundred tons. This fact, coupled with its inherent flexibility of starting and shutting down at will, provides a versatile production melting unit. Though the trend is toward larger units, the specialty shops continue to operate the smaller units to considerable advantage where small heats of special analysis are required, or for making small castings where small heats of steel with high pouring temperatures are needed. Generally, the wider the range of furnace sizes available in a shop, the greater the overall flexibility of work scheduling and consequent production efficiency.

A discussion of plant operation and expansion quite logically leads to consideration of:

Flexibility in Types of Product

It is now well established that, regardless of analysis, steels of the highest quality and superior mechanical properties are produced in the electric arc furnace, largely because of the ease of controlling slag-metal reactions and bath temperatures. The arc furnace is used to melt and refine iron, produce common steels, and the entire family of high quality stainless steels. Whether the product be common low-carbon steel, low-chrome hardening steel, aircraft quality steel, high-carbon bearing steel, electrical steel, high-speed tool steel, permanent magnet steel, cobalt-base heat-resistant metals, or any of the many other high-and-low-alloy grades, the closest metallurgical control of reactions, the transformation of elements, and the maintenance of temperature are demanded. These are easily met requirements for the electric furnace.

The arc furnace can utilize oxidizable alloying elements much more efficiently, and permits recovery of oxidizable elements from the scrap because of flexibility in the oxidizing and reducing periods of the heat. Operating control, both metallurgical

and thermal, is much closer, with the result that, in basic practice, the sulphur content may be readily reduced to very low levels without difficulty. There is no contamination of the bath because the "fuel"—electricity—contains no sulphur or other impurities. This latter condition is of particular importance in assuring the uniformly high quality of all electric arc furnace products.

Flexibility in the Utilization of Scrap

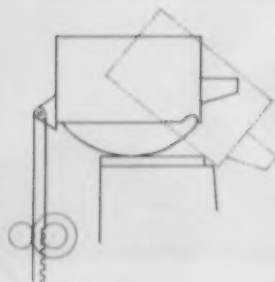
Fluctuating scrap prices point up the importance of flexibility in the types and qualities of materials that can be charged in an electric furnace. The modern top-charge type of furnace operates efficiently on a variety of types and sizes of scrap, ranging from steel turnings and iron borings to crop ends, skulls, heavy melting-scraps bundles and scrap ingots. Even unbound materials can be charged at a considerable saving in scrap cost. Thus the ability to consume most types of scrap without regard to size, weight or density, places the arc furnace steel maker in an enviable position from the standpoint of cost of metallics.

Flexibility in Slagging Practice

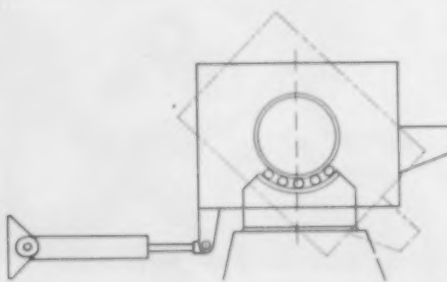
Slag composites used in the arc furnace can be controlled with much greater ease than in other conventional melting processes. The tilting mechanism makes slagging-off a simple operation. This permits the easy establishment of oxidizing, reducing or neutral slags, or any combination or succession of such slags. It also is well known that the arc furnace requires much less slag than other melting furnaces—meaning, of course, there is less slag-material cost, less heat loss, and less metal loss; there also are less slag-making materials to add, handle and dispose of.

Flexibility in the Foundry

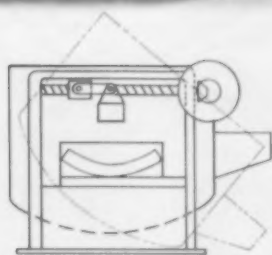
In addition to the broad variety of materials produced in the steel mill, the electric arc furnace is a most flexible unit in the steel foundry. Besides



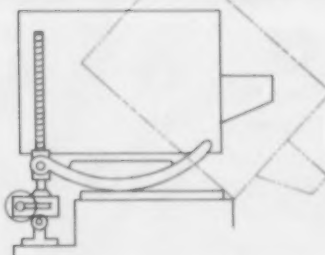
**Bottom Rocker
Rack and Pinion
Operation**



**Side Roller Trunnion
Hydraulic or Screw
Operation**



**Side Rocker
Horizontal Screw and Nut
Operation**



**Bottom Rocker
Vertical Screw and Nut
Operation**

its basic use for melting metals, the same type of furnace is used for off-setting heat losses in foundry duplexing, and as a super-heating furnace to raise the temperature of iron melted in the cupola for pouring large numbers of small castings. It also is used economically to hold steel from a converter when more than one heat is required for pouring very large castings.

Because of its flexibility in size and construction, the electric arc furnace can be located without difficulty in an existing foundry or, when building a new arc furnace foundry, its size and operating characteristics allow many economies in the construction of the buildings.

Flexibility in Design

Much the larger part of new furnace capacity is installed in existing mills and must, in design and construction features, take into account such factors as head-room, materials-handling equipment and floor plan. In this respect, the arc furnace offers flexibility of design which makes it suitable to almost any size and type of operation.

Many different tilting arrangements have been used. The great majority of furnaces now use motor driven tilting means, although hydraulic cylinders are also used where they may be preferred.

Two principal mast and electrode arm arrangements are in use, depending upon the physical limitations of the shop. The arm and crosshead move up and down as a unit in the fixed mast type, while, in some buildings, the crane head-room limitations require the use of the moving mast construction.

Several designs of tilting arrangements and electrode masts are shown in the accompanying illustrations.

Arc furnaces vary from the six-electrode, elliptical-shell type that is over 25 years old and still in operation, to the original prototype, single-electrode, bottom-contact furnace that was the forerunner of today's three-phase, three-electrode, top-

charging units. Many different electrode arrangements are in use—the direct-arc, the submerged-arc, and the indirect-arc of the non-ferrous unit. Of these, the three-electrode, direct-arc type is by far the most commonly used.

Most modern arc furnaces are designed with swing-aside roof for top-charging. They may, however, be designed for side-charge by hand, chute, or machine.

Ideal planning recommends a shop designed to make full use of the flexibility and broad adaptability of the electric furnace.

Flexibility in Plant Location

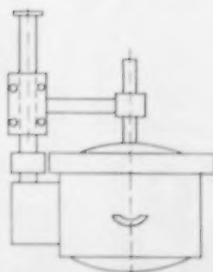
The electric furnace plant can be located almost anywhere, since it is not dependent upon coal, gas, or coal-tar products for fuel. Areas having abundant electric power can be utilized. This makes possible decentralization, bringing the product much closer to the consumer market. The building of a number of smaller plants at strategic locations, rather than the single, large, centralized plant, offers many ways to reduce product cost by taking advantage of lower freight rates, lower power cost, a favorable labor market, and greater availability of raw materials. The electric furnace, being readily portable, never becomes a fixed part of the land.

Flexibility for the Future

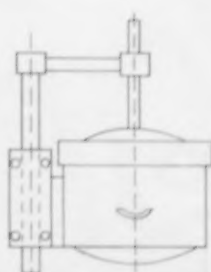
The future of electric arc furnace steel operations can be projected only by using the past and the present as a guide—but this must never become a limitation. These things we do know:

Everyone within the steel industry favors the electric furnace over all other types for cold-melt practice, and there is increasing use of hot metal in the electric furnace. As process methods are developed in the future, duplexing and triplexing will become more prominent, using the arc furnace as the unit to absorb the remelt scrap, as well as to refine and adjust final analysis.

(Concluded on last page)



**Fixed Mast
Moving Crosshead
and Arm**



**Moving Mast
and Arm**

CARBON FOR RUN-OUT TROUGH LININGS

THE BROAD acceptance and rapidly increasing use of carbon and graphite in the making, working and fabrication of metals have vastly increased the industry's knowledge of the properties of these two materials.

In many cases carbon and graphite are the only materials that have been successful in meeting the severe and exacting requirements involved in handling hot metals and corrosive slags. This is due to their well-known properties, such as: they are not wetted by molten metals and thus, the metal does not stick to them; they maintain their mechanical strength well past the temperatures attained in handling molten metals and slags; they do not suffer deformation at high temperatures; their resistance to thermal shock obviates spalling and consequent inclusions or other undesirable effects of ceramics; their negligible thermal expansion assures uniformity in size and shape under all heat conditions; their light weight facilitates handling. Since these properties always have been basic requirements in metallurgical industries, carbon has become the logical choice of economical materials for a great many applications.

Blast Furnace Run-Out Troughs

Carbon in standard block shapes is in wide-spread use for run-out trough linings from the taphole

to the splash plate. For lining the iron basin and runners, standard carbon brick shapes should be used. The use of large carbon blocks effects a considerable saving in the cost of installing a run-out trough lining because much less time is required to handle and place fewer pieces, while chipping and fitting are reduced to a minimum.



The carbon lining is built up of three-piece sections, each consisting of two side blocks and one bottom block laid into a ceramic-lined trough. Conventional cast iron or refractory constructed troughs may be lined with standard carbon bricks or slabs, with the voids between the carbon shapes and the trough filled with ceramic brick bonded with carbonaceous cement between the carbon brick and the ceramic. As a result of this construction, repairs can be made to necessary sections without replacing the whole construction.

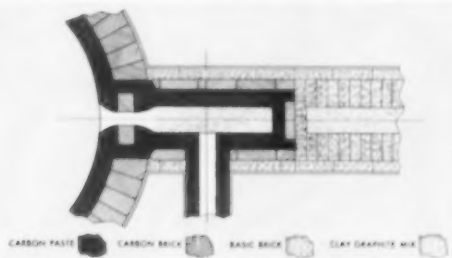
Since iron does not stick to the carbon, iron



draining from a carbon runner is exactly like mercury draining from a glass plate. If the iron is cold and of high sulphur content, a skull forms in the runner, but it always is loose and easily removed. Oxidation can be prevented by brushing the carbon with a clay slurry before each tap. The disagreeable and costly maintenance of troughs is greatly reduced, there is no delay in tapping, and the metal is clean.

Neither does slag stick to carbon, so that the same lining practice employed for iron runners applies equally well to slag runners.

Cupola Run-Out Trough and Dam Linings



The same characteristics of carbon in the form of bricks, shapes and paste are found to be ideal for cupola run-outs and dam linings also.

In this case the practice of lining troughs and

runners differs somewhat from that of the blast furnace because of the inherent differences in operation dictated by the nature of the furnaces. While these differences are less pronounced with back-slugging cupolas, the growing interest in front-slugging has presented chemical and metallurgical problems which require a different concept of linings for the slag dam and iron trough.

On basic cupola, the trough between the taphole and the slag dam is lined with rammed carbon paste, with the dam itself being constructed of a solid block of carbon, faced with a coating of carbon paste approximately $4\frac{1}{2}$ " thick. The run-out trough is lined with ceramic brick against the trough, then faced with carbon brick and, finally, a thick coating of carbon paste.

Carbon has proved itself a superior refractory in the front-slugging spout where it is of utmost importance to select and properly install good refractories. The refractory at the top of the dam is subjected to slag attack; while nearer the bottom, and also in the runner, it is eroded by the iron. Because the construction of the dam determines its operation, dimensions are quite critical; this means that lack of lining stability can change the dimensions sufficiently to allow air leakage through the taphole, making it necessary to reduce the air pressure or stop the operation for repairs.

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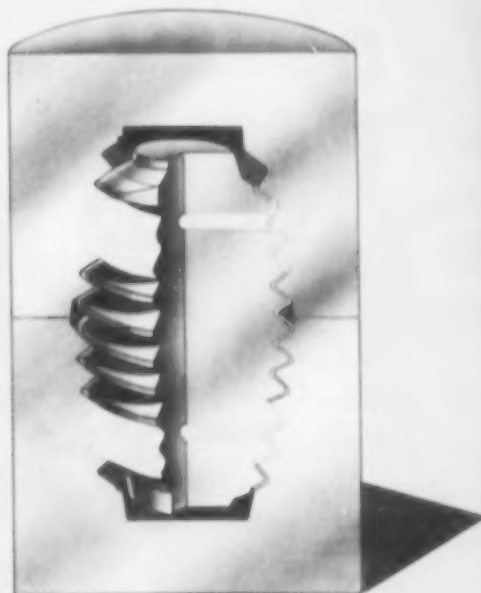
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**Patents Pending*



FLEXIBILITY OF THE ELECTRIC ARC FURNACE —WHAT IT MEANS TO THE STEEL PRODUCER

(Conclusion)

The submerged-arc furnace is the key to the ever-expanding production of such products as phosphorus, calcium carbide, silicon, and the ferrous and non-ferrous alloys.

Still other new fields of arc-furnace utilization are the recovery of lead, zinc, and other metals from slags, while some steel-makers are using arc furnaces to make special slags which are added to the ladle. This last usage is the Perrine (French slag) process which has received very favorable comment.

Centrifugal casting and the continuous casting of steel owe a measure of their success to the electric arc furnace as an ever-ready reservoir of hot metal at proper temperature and analysis. Nodular iron, as applied to shell molding, is expediently made in the arc furnace by spout addition of nodularizing alloys. Of outstanding interest also is a vast array of new "specialty" alloys. All of these products are economic and metallurgical successes only because of the electric arc furnace.

An entirely new field, that of vacuum melting, is now being explored. Melting in a vacuum, or in an atmosphere of inert gases, is an absolute necessity for oxygen-sensitive metals. Research in this field has shown that the use of this process in the production of other alloys and special steels imparts surprising and undreamed-of properties to the product. There are many problems to be solved in

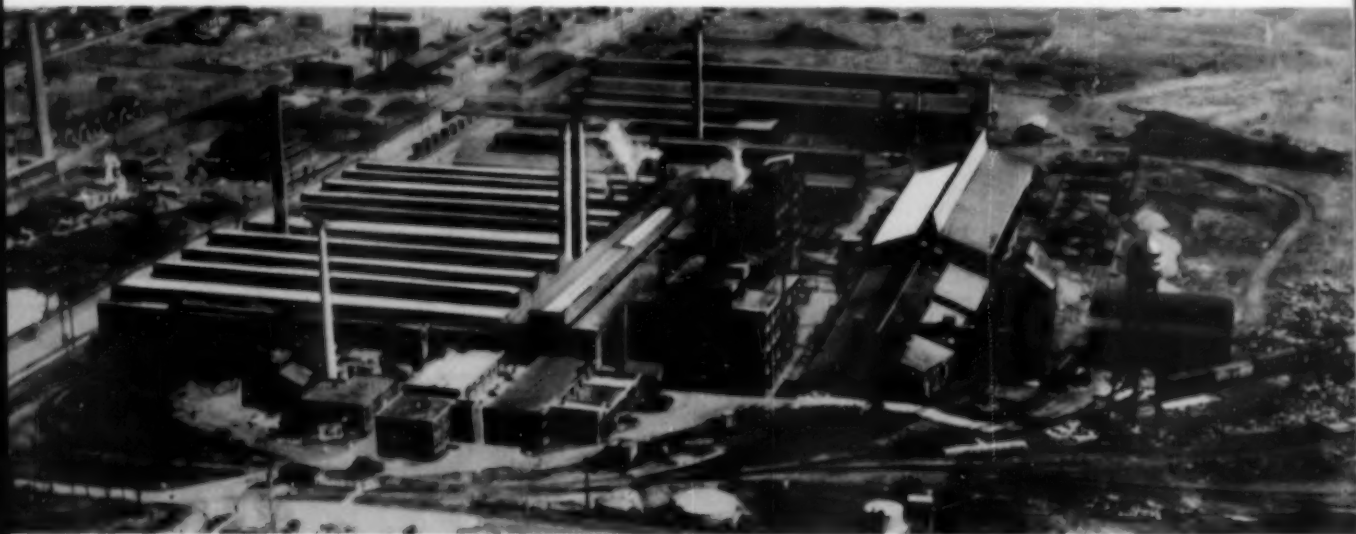
this development, but favorable progress is assured.

Competition is becoming keener. The effort to improve product quality and reduce its cost never has been greater than at present. Whether to expand or contract plant capacity, or alter its physical structure and facilities, requires serious decisions by management. Such decisions involve long-range forecasting, millions of dollars, and a combination of sound judgment, logic, and an unshakeable faith in the future. The electric arc furnace can play a decisive part in meeting these requirements of the future.

Summary

The electric arc furnace has been examined as a FLEXIBLE unit that is: "*readily adjustable to meet requirements; susceptible to modification or variation; manageable and adaptable.*" Seven major requirements of the steel mill and steel foundry have been analyzed in terms of the electric furnace. It has been found that no other method for melting, smelting, reducing and refining metals and alloys satisfies all these closely defined needs as fully as the electric arc furnace.

EDWARD A. HANFF received his B.S. degree in Electrical Engineering at Worcester Polytechnic Institute in 1910. Following service as a controller engineer with Westinghouse Electric Corporation, he became associated with the early design and development of electric arc furnaces in 1917. Since that time, he continuously has been engaged in the application of industrial furnaces of various kinds and is now Vice President, Swindell-Dressler Corporation, Pittsburgh, Pennsylvania.



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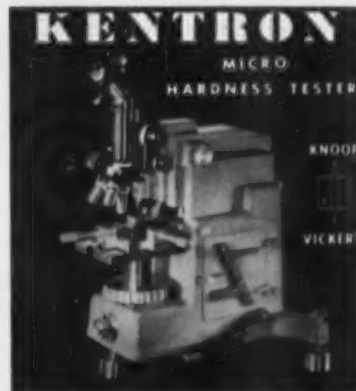
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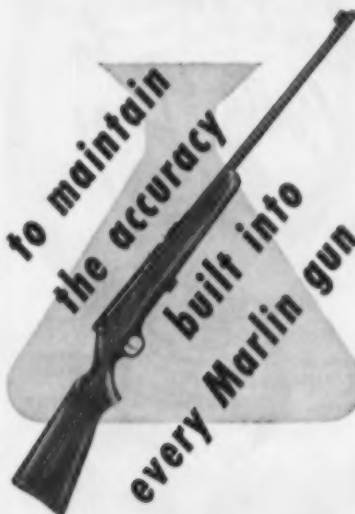


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Jackson 1-4200

LIST NO. 116 ON INFO-COUPON PAGE 61

METAL PROGRESS; PAGE 56

RUST-LICK
IN
AQUEOUS SYSTEMS

Grade "C-W-25"

*Non-flammable
Non-toxic*

*Aqueous Oily Film
Protects Ferrous Parts
for Long Periods
Indoor Storage*

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Specify Grade "C-W-25"

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MANHATTAN

**Abrasive Wheels — Cut-off Wheels
Finishing Wheels—Diamond Wheels**

Custom-made for your specific
material removal problems

**Foundry Snagging—Billet
Surfacing—Centerless Grinding**

**Cutting and Surfacing concrete
granite, and marble**

"Moldises" for rotary sanders

**Grinding and Finishing
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**Bearing Race Grinding
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Finishing Tools and Cutlery

**Cutting-off—Wet or Dry Bars, Tub-
ing, Structural, etc. Foundry Cutting**

—standard and reinforced wheels

Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.

MANHATTAN RUBBER DIVISION

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BRIGHT HARDENING SPECIALISTS



THESE Stainless Steel Aircraft Parts,
Hardened at 2000° and Over, Remain
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Change . . . A Tribute to STANDARD'S
Craftsmanship and Exclusive Processing.

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WHITELIGHT MAGNESIUM

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Tubes • Rods • Shapes • Bars
Hollow Extrusions • Plate • Sheet
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Sales Office
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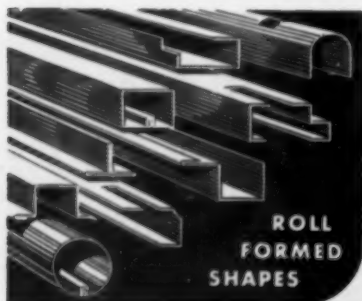


To ensure uniform high quality and closer tolerances, American Non-Gran Bronze uses statistical quality control in its contract machine work. Learn what this can mean to your product. Write! AMERICAN NON-GRAN BRONZE CO., Berwyn, Pa.



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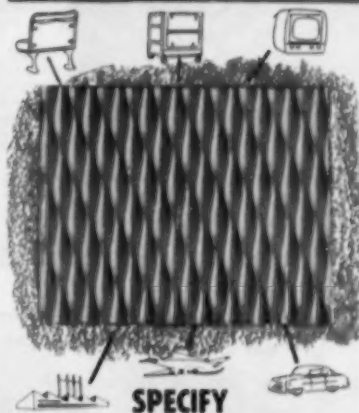
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Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

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STRENGTHEN BEAUTIFY PROTECT your product



SPECIFY

RIGID-tex METALS

Take that new product of yours, make it dent-scruff-scratch-resistant, give it plenty of rugged impact resistance, reduce its weight and double its strength, and finish it up by packing it full of buying-eye appeal. You can do all this when you specify Rigid-Tex Metals right into your product designs! Find out for yourself.

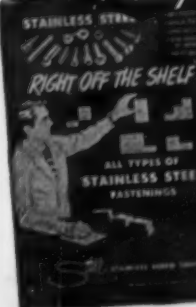
Send for new 16-page complete catalog—on company letterhead, please—or see Sweets Catalog Ia/Ri.



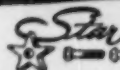
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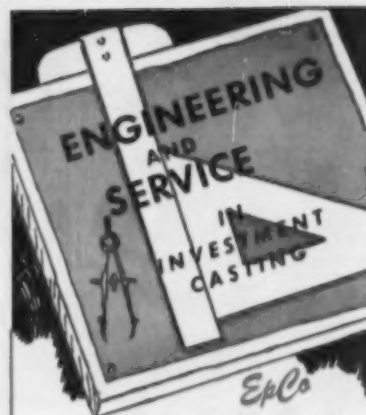
BOLTS & CAP SCREWS
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Star Stainless Screw Co.

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EpCo

A PROVEN DEPENDABLE SOURCE FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS



INVAR
CASTING
Special Feature
—Nickel content
held to 35% min-
imum — 36%
maximum

STAINLESS STEEL PART for milk
bottling unit formerly machined
from solid stock.
Only finish oper-
ations required
are reaming small
dia. of counter-
bored hole and
drilling and tap-
ping for set screw.



ENGINEERED PRECISION CASTING CO.

MORGANVILLE, N. J.

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Send samples
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sub-assemblies.



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Electrode*

See
Maurath, Inc.
For

**Stainless and
Heat Resistant
ARC WELDING
ELECTRODES**

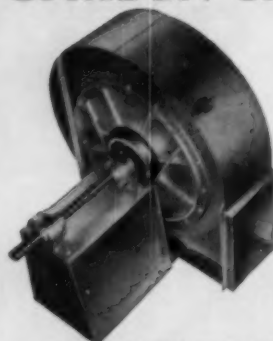
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GARDEN CITY Industrial FANS



For a wide choice . . . GARDEN CITY FANS designed with FORWARD — BACKWARD — or RADIAL BLADES, serve many industrial processing requirements.

If your needs call for HIGH TEMPERATURES (300° to 1600°F) you'll find GARDEN CITY HIGH TEMPERATURE FANS save you money. Patented air-cooled shaft slices maintenance costs.

Send for our latest catalogs, illustrating GARDEN CITY INDUSTRIAL FAN equipment. For specific details, outline your fan problems to us, giving cubic feet per minute, static pressure, and just how you intend to use the fan. We'll be pleased to suggest a fan for you.

GARDEN CITY FAN COMPANY

332 South Michigan Avenue — Chicago 4, Illinois

Representatives in principal cities



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GET A BID FROM

HOOVER

SPECIALISTS IN THE FIELD OF

Die Castings

SINCE 1922
Aluminum and Zinc



THE HOOVER COMPANY
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USE OUR

HOEGANAES SPONGE IRON POWDER

for

*Powder Metallurgy
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OTHER NON-FERROUS

ROUND WIRE FLAT

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IN 10 SECONDS!**



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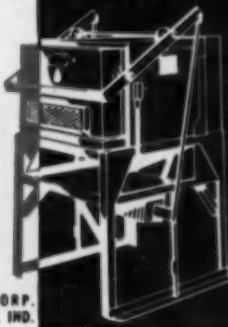
Expand Your Plant Potential

WITH *Cooley* ELECTRIC HEAT TREATING FURNACES

fast... inexpensive way to expand your plant facilities. Choose from 27 Models.

For instance:

1. You save time and money by keeping heat treat jobs for small parts in plant.
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Write now for Catalog giving complete details.

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Style #13 in salt hardening bath application.

Representative Inquiries Invited.
Specialists in Processing Carriers Since 1932

Wiretex

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FOR ALL YOUR
BASKET and FIXTURE
NEEDS...

Call Wiretex

Wiretex has the facilities to serve your every need. Small, large, standard or custom built. To resist acid, heat, corrosion or exposure. In every shape, metal and alloy. Prove it to yourself—send for the Wiretex catalog today!

BASKETS • RETORTS
MUFFLES • GRIDS
SCREENS • RACKS
for Quenching, Carburizing,
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HARDEN, QUENCH,
WASH, and
TEMPER



in one continuous operation
AUTOMATICALLY

Parts are conveyed automatically through 2 gas-fired hardening furnaces and into the quench tanks, from which the lines converge for direct conveyance to the **METALWASH** Spray Washer, where quenching oil is removed prior to tempering.

The **METALWASH** Spray Washer conveys the work directly into the continuous tempering unit. Combination washing and tempering machines also available.

Write today for information about the **METALWASH** way to Heat, Quench, Wash and Temper **AUTOMATICALLY**.



METALWASH MACHINERY CORPORATION
908 North Avenue, Elizabeth 4, N. J.
In Canada, Canefco, Ltd., Toronto, Ontario

LIST NO. 117 ON INFO-COUPON PAGE 61



and **STANWOOD** has the Experience!

For nearly a quarter century Stanwood Heat Treating Equipment has been the standard in Heat Treating Shops — job and captive shops — all over the country. Stanwood has designed and built every conceivable type of basket, tray, fixture, and carburizing box to handle parts through heat treating, as well as retorts and furnace parts. Look to Stanwood for a practical, economical solution of your problems. Write for catalog.

Stanwood

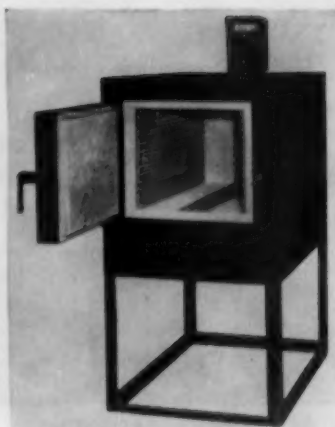


Corporation

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More than two thousand satisfied users
WILL TESTIFY YOU
**SAVE 3 WAYS
WITH A LUCIFER FURNACE**

1—Save on First Cost

CHECK THESE PRICES

Furnace Size	2000°	2300°
6x6x12"	\$ 580.00	\$ 600.00
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Complete with 100% automatic
electronic controls.

2—Save on Man Hours

Less operator attention needed—Lucifer controls
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and retain SPECIFIED temperature without varia-
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a Lucifer Furnace.

3—Save on Maintenance

Finest refractory materials are built into Lucifer
Furnaces for better, more efficient heat retention.
Elements are guaranteed, long lived, trouble free.

WRITE FOR FREE LITERATURE, specifications
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of sizes—top loading and side loading types.
Engineering advice without obligation. Write,
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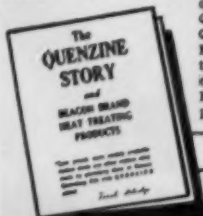
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the QUENZINE STORY

Low priced, more readily available carbon
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Quenching Oils with
QUENZINE added.
For information on
this new additive and
other Beacon Brand
Heat Treating Com-
pounds write to . . .



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GAS, OIL AND ELECTRIC
BATCH • CONTINUOUS

ATMOSPHERIC-RECIRCULATING-
PUSHER—ROTARY HEARTH—
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"Tailored by Dempsey"



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CIRC-AIR

**HEAT TREATING
FURNACES**

for
Every Heat Treating
Process

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**CONTROLLED
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DIRECT FIRED

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**CIRC-AIR DRAW
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Specially Engineered
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(for surface hardening stainless steels)

what it is... what it does... how it works
... how you can use it.

Write today for your copy of this 24-page
booklet. Specific subjects discussed include
... pretreating the steels... selective Mal-
comizing... case depth... wear resistance
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A special "case history" section shows
how nationally known manufacturers are
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Lindberg Steel Treating Co., covering in-
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plants in Rochester, Chicago, St. Louis and
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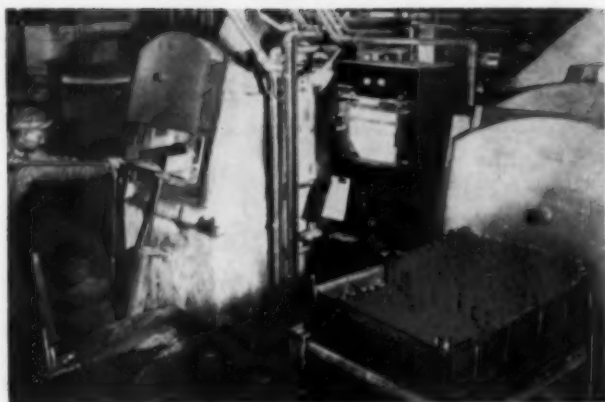
LINDBERG STEEL TREATING COMPANY
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Phone: PIlmora 4-4880. St. Louis 15, Mo., 650
S. Taylor, Phone: 894-9900. Los Angeles
23, Calif., 7910 So. Sunset Drive, Phone: ARI-
go 1-7817. Rochester 11, N.Y., 420 Buffalo Rd.,
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CHICAGO • LOS ANGELES • ROCHESTER • ST. LOUIS

LINDBERG STEEL TREATING CO.

LIST NO. 38 ON INFO-COUPON PAGE 61

METAL PROGRESS; PAGE 60



**Makes SMALL PARTS
GROW . . . in Value!**

Carbonitriding by
LAKE SIDE

Plus these comprehensive, complete scientific steel treating services: Electronic Induction Hardening, Carbonitriding, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Sand Blasting, Laboratory Physical Testing.

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Upton

.... OFFERS
the most advanced
Salt Bath Furnaces
FOR

BATCH
TYPE
WORK

o

CONVEYORIZED
TYPE
WORK

o

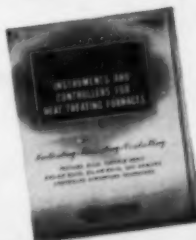
ALUMINUM
BRAZING



UPTON ELECTRIC FURNACE CO.
16808 Hamilton Avenue
Detroit, Michigan
Phone: Diamond 1-2520

LIST NO. 20 ON INFO-COUPON TO RIGHT

**Instruments and Controllers
for heat treating furnaces**



A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO₂ recorders are covered.

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THE HAYS CORPORATION
Michigan City 26, Indiana

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4-point service

Westinghouse, manufacturer of gas, oil and electric heat-treating furnaces, offers an expanded and comprehensive service to help you get maximum speed, quality and dollar savings from your heat-treating operation. The savings realized stem from Westinghouse ideas, know-how and manufacturing capacity.

In scope, this service ranges from unbiased recommendations of fuel, equipment and control devices through manufacturing, packaged installation and proper maintenance of your heat-treating system.

Call your nearest Westinghouse sales office for complete information . . . ask for *The Man With The Facts* on industrial heat-treating.

Les Gillette, Sales and Order Service Mgr., Westinghouse Industrial Heating Division, explains how this exclusive service brings greater economy to your heat-treating operation.



Westinghouse engineers study your plant arrangement, talk to company engineers and dig into every phase of your heat-treating picture. With unbiased recommendations, these Westinghouse specialists often point out new techniques that could improve operations.



Unique production line techniques permit close quality checks on furnace manufacturer from point of initial materials through final assembly and testing. Above is one in-line assembly and testing area in the Westinghouse Meadville plant.

gives you more heat-treating per dollar . . .

1. Engineering consultation and recommendations—Westinghouse engineers, experienced in all phases of heat-treating, thoroughly analyze your problems firsthand. They'll talk things over with your engineers, then make unbiased recommendations as to type of basic and auxiliary equipment most suitable for your needs.

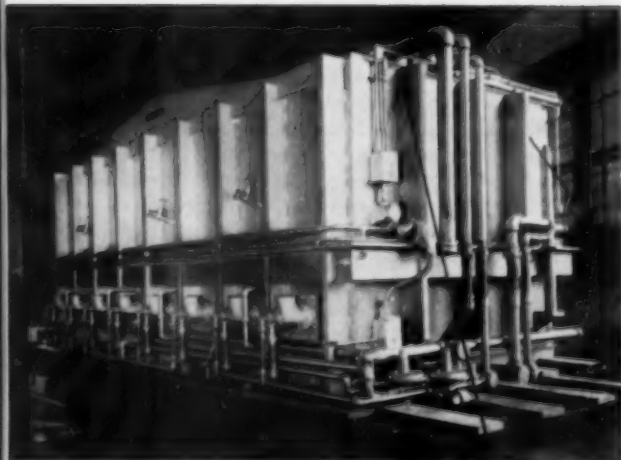
2. Skillful equipment design—Most of our design engineers have at least 14 years' experience in the erection, operation and maintenance of industrial furnaces. This background of factory and field know-how makes advanced and skillful furnace design the rule at Westinghouse . . . design that assures heat-treating to highest quality, speed and economy standards.

3. Quality manufacturing techniques—Furnaces tailored to your requirements are manufactured entirely within the Westinghouse plant on a production line procedure. This means close quality checks, by experts, during every step of assembly . . . means packaged equipment and pinpointed responsibility.

4. Unique packaged installation—Installation of completed equipment is done in one quick operation. Everything is shipped intact . . . no assembly work required in your plant. Westinghouse installation teams are thorough and efficient. What's more, Westinghouse engineers establish maintenance procedure for you and check back periodically to assure peak efficiency from equipment.

J-10438

YOU CAN BE **SURE**...IF IT'S
Westinghouse



Westinghouse ships erected furnace sections with parts fitted and matched. This pre-packaged shipment saves you storage and handling problems. Westinghouse will supervise or undertake complete furnace erection and installation, thereby assuring peak operating efficiency.



Put this service to work for you!
For more information, mail this
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Westinghouse Sales Office.

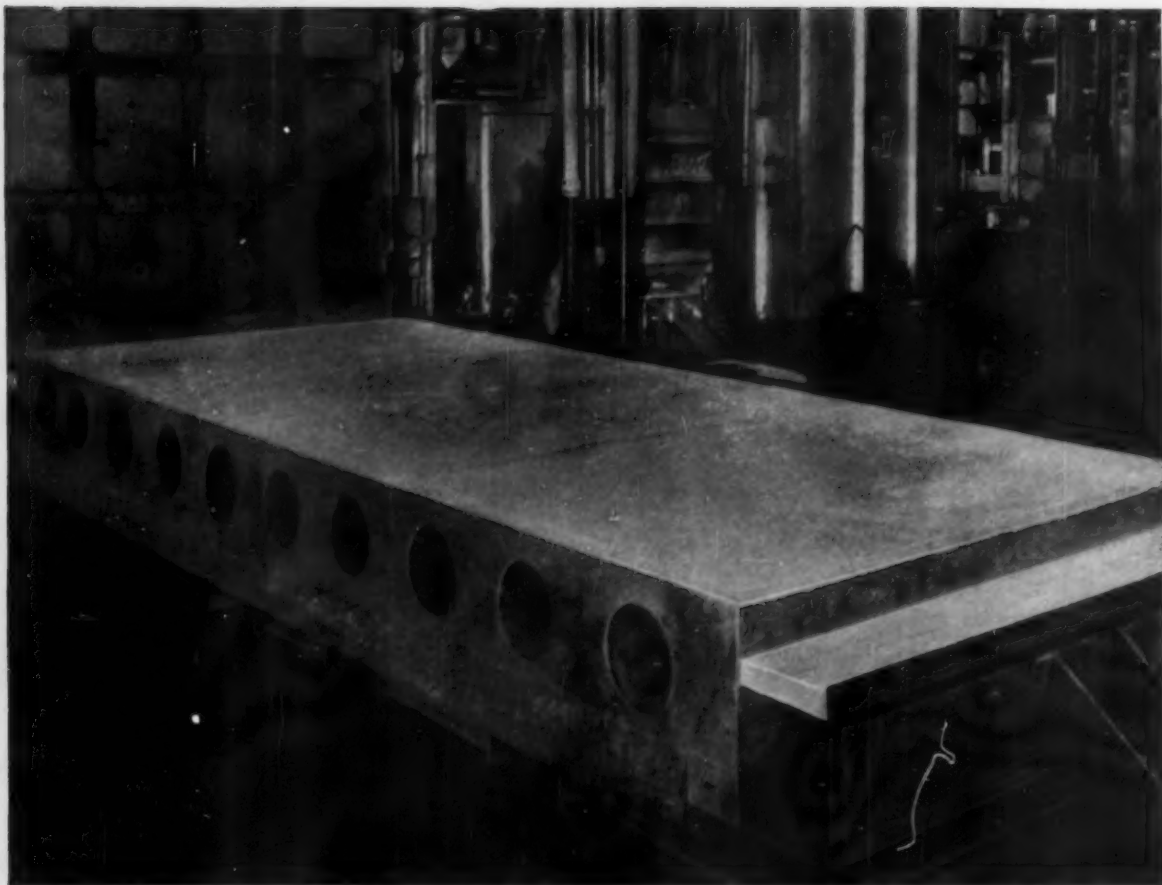
Westinghouse Electric Corporation
3 Gateway Center, P. O. Box 868
Pittsburgh 30, Pennsylvania

- ☐ Please have your representative call
- ☐ Please send more information on your new
heat-treating service

Name

Company

Address State



REFRACTORY CONCRETE CAR TOP in use at Commercial Steel Treating Co., Detroit, Mich. This car top is made with Zero ZR-13, a Lumnite-base castable produced and marketed by Standard Fuel Engineering Co., Detroit, Mich. For over 15 years this company has used refractory concrete for car tops and furnace door linings.

Why does refractory concrete make the best furnace car top?

EASY TO CAST—TROUBLE-FREE SERVICE! Despite repeated thermal shock and temperatures to 1850° F., Refractory Concrete car tops on this particular job gave more than twice the service life of car tops made with previously used materials.

These durable car tops need less maintenance . . . cut over-all costs. Smooth, one-piece sections form an even, level base for castings. And they are easy to make with Lumnite® calcium-aluminate cement and refractory aggregates.

For added convenience, you can use a Lumnite-base

castable mix—Lumnite cement plus aggregates selected for specific temperature and insulation needs. All you do is add water, mix and place. Castables are made and distributed by leading refractory manufacturers.

You'll find Refractory Concrete made with Lumnite cement excellent for use wherever heat, corrosion or abrasion are problems. Easy to place—by plastering, pouring or cement gun—and it's ready for use within 24 hours! For more information, write Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

OFFICES: Albany, Birmingham, Boston, Chicago, Dayton, Kansas City, Minneapolis, New York, Philadelphia, Pittsburgh, St. Louis, Waco.

"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

WP-L-100

ATLAS®

LUMNITE for INDUSTRIAL CONCRETES

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT



UNITED STATES STEEL HOUR—Televised alternate weeks—See your newspaper for time and station.



**standard for comparison
...and with high speed steels
the standard is REX**

Living up to a standard for comparison isn't easy. That's why Crucible lavishes special care on the manufacture of REX® high speed steels...to keep REX the *standard* wherever high speed steels are used—as it has been for over half a century.

It's easy to *prove* the superiority of REX. Use it on the job...check its size, structure, response to heat treatment, fine tool performance. You'll agree with thousands of other users—you *can't find a high speed steel to outperform REX.*

Remember, REX is made only by Crucible. So call for REX at any Crucible warehouse, or for quick mill delivery. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

Visit us at Booth 350
Western Metal Show
Los Angeles—Mar. 28-Apr. 1

CRUCIBLE

first name in special purpose steels

Crucible Steel Company of America

MARCH 1955; PAGE 65

A SPECIAL REPORT ON PROTECTIVE FINISHES FOR ALUMINUM

Most aluminum producers and fabricators are well aware of the superiority of chemical finishes over anodizing for the protection of aluminum from corrosion. Naturally, then, there is a running battle for acceptance among the leading producers of the protective chemical finishes.

That's why, here at Allied, we have always studied your needs with regard to both our own and competitive processes. We're constantly trying to produce new and better finishes because we believe there's always room for improvement . . . even to our own products. Some years ago this policy led to the introduction of a process, long in development, that offered you a way to overcome anodizing's obvious technical complications . . . Iridite #14. This finish was far easier to use than anodizing, yet provided comparable, if not superior, quality. And, its cost was much less than anodizing.

But other finishes offering similar advantages over anodizing have entered the market. So . . . the current battle for acceptance. By any cost comparison Iridite #14 is the most economical. However, corrosion tests by users show contradictory results as to performance from Iridite #14 and other leading protective finishes for aluminum. Most tests show Iridite #14 superior, but some do not. The margin of difference, however, is always small. The truth is that all have proved good. However, our laboratory research indicated that still further improvements could be made.

That knowledge . . . plus our aim to give you even better protection and maintain the leadership of the industry, is exactly why Allied Development Engineers have been working for long years to develop a better finish than any of those now available, including our own Iridite #14.

Now the new finish is ready for you. It's called Iridite #14-2 (Al-Coat).

From a performance standpoint, Iridite #14-2 gives you two important advantages in the protective finishing of aluminum.

FIRST: in its fully colored brown film stage it provides corrosion resistance decidedly superior to previous processes.

SECOND: the basic brown film can be hot water bleached to produce a clear-type film with protection heretofore unobtainable from clear-type chemical finishes.

From an operating standpoint, new Iridite #14-2 gives you three important advantages.

FIRST: it provides consistently

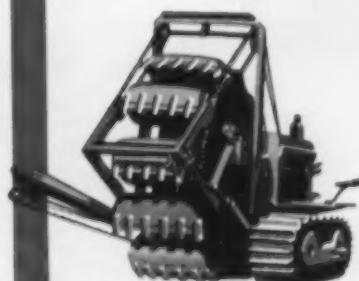
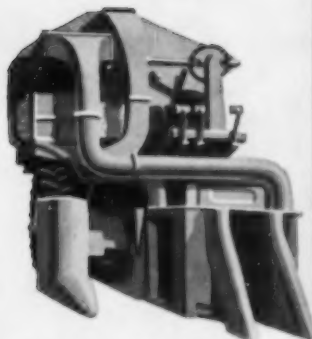
higher corrosion resistance for different aluminum alloys treated in the same bath.

SECOND: it provides a more uniform appearance for parts of different alloys and with varied surface finishes before treatment.

THIRD: its operating and technical characteristics are superior to those of other processes.

If you are using or planning to use a chemical finish for aluminum, you should have full details on new Iridite #14-2. Write us or send samples for free test processing. Or, for more immediate advice, call your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book. - - - ALLIED RESEARCH PRODUCTS, INC., 4004-06 EAST MONUMENT STREET, BALTIMORE 5, MARYLAND.

P. S. Even new Iridite #14-2 will be constantly measured against both your needs and competitive processes to make sure you get the best possible, most economical finish for your product that man and the laboratory can develop.



You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel—it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

Service life doubled ...with Inconel

How The Timken
Company makes
fixtures that stand
2700 hours of
carburizing and
oil quenching



How long do *your* quenching fixtures last? And how much do they have to take? Perhaps the experience of The Timken Roller Bearing Company can help you save on replacement costs.

Roller bearing parts at The Timken Company are carburized in natural gas. This heat treatment is followed by an immediate oil quench.

During the whole process the parts are carried on a fixture consisting of three Inconel® eye-bolts welded to a grid. Formerly, under the corrosive conditions and severe thermal shock, eye-bolts only lasted an average of 1350 hours.

With Inconel, The Timken Company finds the service life of these eye-bolts has been doubled, and better. Some last up to 3700 hours.

This is possible because of Inconel's combination of valuable properties: its strength at high temperatures, its excellent resistance to oxidation and corrosion, and to thermal shock.

With these factors present, fabricated, well designed Inconel equipment is the logical choice for heat treating service followed by quenching. Of further importance, Inconel, despite its strength and toughness, can be readily formed. It is also easy to weld by any of the commonly used methods.

Try Inconel. You'll find, like The Timken Roller Bearing Company, that it is a high temperature alloy that gives long service under severe conditions. And for many suggestions on practical ways to make Inconel heat treating equipment write for our booklet, *Keep Operating Costs Down . . . When Temperatures Go Up.*

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

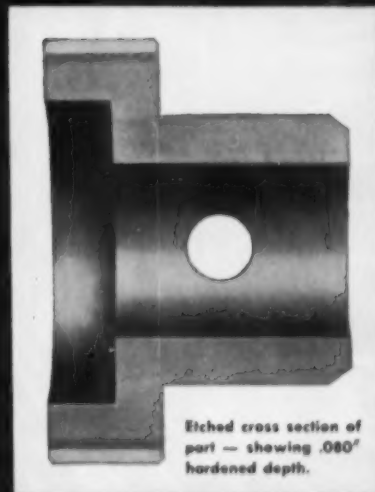


Nickel Alloys



Inconel . . . for long life at high temperatures

COSTS CUT 94%



with TOCCO* Induction Heating

A cost reduction of 94% resulted when heat-treatment of this Corn Harvester part was changed from carburizing to TOCCO-hardening. Look at the unit cost breakdown:

CARBURIZING		TOCCO-Hardening	
Degrease.	\$0.0020	<i>eliminated</i>	
Carburize.	0.0200	<i>eliminated</i>	
1st quench	0.0150	TOCCO, heat and quench	\$0.0060
2nd quench.	0.0150	<i>eliminated</i>	
Draw	0.0050	<i>eliminated (self-draw)</i>	
Shotblast.	0.0035	<i>eliminated</i>	
Internal Grind	0.0243	<i>eliminated</i>	
External Grind	0.0166	<i>eliminated</i>	
	<u>\$0.1014</u>		<u>\$0.0060</u>

"—Savings of 9½ cents per piece—\$4770.00 on each 50,000 piece batch, plus an hourly production increase from 120 to 300 pieces per hour, plus improved quality of the product by virtue of the deeper case and stronger core."

Have you investigated TOCCO's cost-savings possibilities for your hardening, brazing, melting or forging operations? Why not write us today or send blueprints of your parts —no obligation, of course.

THE OHIO CRANKSHAFT COMPANY



NEW FREE BULLETIN

Mail Coupon Today

THE OHIO CRANKSHAFT CO.
Dept. R-3, Cleveland 1, Ohio
Please send copy of "TOCCO Induction Heating."

Name _____
Position _____
Company _____
Address _____
City _____ Zone _____ State _____



Aimed right at your alloy needs the world's largest alloy steel stocks

Thousands of tons of certified alloy steel in 1698 different sizes, shapes, analyses and conditions await your call at Ryerson. New leaded alloys are on hand in three different carbon ranges. Standard analysis steels are supplemented by a wide range of aircraft quality alloys. No matter what your alloy requirement, you can depend on Ryerson for quick delivery of highest quality steel.

You won't need to check or test your dependable Ryerson alloys before you use them because every bar has been spark tested and identified with its own heat symbol—every heat has been hardenability tested for you as part of an 8-step quality control plan. And should problems of application or fabrication arise, Ryerson al-

loy metallurgists will gladly put years of practical experience to work for you.

No order is too large to fill from stock, no order too small for quick personal service—so, next time you need alloy steel call your nearby Ryerson plant.

PRINCIPAL PRODUCTS

CARBON STEEL BARS—Hot rolled & cold finished.

ALLOYS—Hot rolled, cold finished, heat treated.

STAINLESS—Allegheny bars, plates, sheets, tubes, etc.

TUBING—Seamless & welded, mechanical & boiler tubes.

STRUCTURALS—Channels, angles, beams, etc.

PLATES—Many types including Inland 4-Way Safety Plate.

SHEETS—Hot & cold rolled, many types & coatings.

MACHINERY & TOOLS—For metal fabrication.



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JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • PHILADELPHIA • CHARLOTTE, N. C. • CINCINNATI • CLEVELAND
DETROIT • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Western Metal Congress and Exposition

Los Angeles, March 28 through April 1, 1955

Cooperating Societies

AMERICAN SOCIETY FOR METALS
AMERICAN CERAMIC SOCIETY
AMERICAN ELECTROPLATERS SOCIETY
AMERICAN FOUNDRYMEN'S SOCIETY, Los Angeles Chapter
AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Metals Branch
AMERICAN ORDNANCE ASSOCIATION, Los Angeles Post
AMERICAN SOCIETY OF CIVIL ENGINEERS
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Southern California Section
AMERICAN SOCIETY OF REFRIGERATING ENGINEERS
AMERICAN SOCIETY OF SAFETY ENGINEERS

AMERICAN SOCIETY FOR TESTING MATERIALS
AMERICAN WELDING SOCIETY
CALIFORNIA SOCIETY OF PROFESSIONAL ENGINEERS, Los Angeles Chapter
INDUSTRIAL HEATING EQUIPMENT ASSOCIATION
INSTITUTE OF THE AERONAUTICAL SCIENCES, Los Angeles Section
PACIFIC COAST ENAMELERS CLUB
PACIFIC COAST GAS ASSOCIATION
PURCHASING AGENTS ASSOCIATION OF LOS ANGELES
SOCIETY FOR NONDESTRUCTIVE TESTING
SOCIETY OF AUTOMOTIVE ENGINEERS
SOCIETY OF WOMEN ENGINEERS
SOUTHERN CALIFORNIA INDUSTRIAL SAFETY SOCIETY
STRUCTURAL ENGINEERS ASSOCIATION OF SOUTHERN CALIFORNIA

SERVING the metal manufacturing and fabricating industries of the West, the 9th Western Metal Congress and Exposition, to be held in Los Angeles March 28 through April 1, will reflect the increasing size and diversity of western metal industries.

The Congress and the Exposition are both sponsored by the American Society for Metals with the help of 23 cooperating technical societies. Five of these will have formal programs of technical papers or panel discussions, as listed on the following pages.

The Western Metal Exposition, with more than 350 exhibiting firms, will completely fill the Pan-Pacific Auditorium and two large pavilions, totaling 150,000 sq.ft. of floor space. Registration to attend the Exposition will be free to all who carry membership cards in any of the 24 co-sponsoring societies. In addition, invitations are being distributed by exhibitors to customers and prospects. The Exposition will

be open from 12 until 10:30 p.m. daily, Monday through Wednesday, and from 10 until 6 p.m. Thursday and Friday.

All sessions of the five societies presenting technical programs will be held at the Ambassador Hotel in Los Angeles. Attendance at the sessions of A.S.M., American Welding Society, Industrial Heating Equipment Association, and the Los Angeles Chapter of the American Foundrymen's Society, is free to anyone attending the Congress. Attendance at the meetings of the Society for Nondestructive Testing is free to S.N.T. members, with a charge of \$2.00 to nonmembers for the educational sessions and \$5.00 for the entire week's sessions; these charges may be applied toward membership in the Society if desired. All of the meetings sponsored by the American Society for Metals will be of the panel type with subjects assigned to various experts, as shown in the program on pages 73 and 74.

• CONSOLIDATED PROGRAM •

9th Western Metal Congress

Los Angeles, March 28 through April 1, 1955

AMERICAN SOCIETY FOR METALS

AMERICAN WELDING SOCIETY (A.W.S.)

SOCIETY FOR NONDESTRUCTIVE TESTING (S.N.T.)

LOS ANGELES CHAPTER, AMERICAN FOUNDRYMEN'S SOCIETY (A.F.S.)

INDUSTRIAL HEATING EQUIPMENT ASSOCIATION (I.H.E.A.)

All Meetings at Ambassador Hotel, Los Angeles

Monday, March 28

- 10:00 a.m. ⚙ Die Materials and New Forming Methods
10:00 a.m. A.W.S. Welding Research
Morning S.N.T. Educational Session
2:00 p.m. ⚙ Today's Titanium Problems and Opportunities
2:00 p.m. A.W.S. Welding of Hardenable Steels
Afternoon S.N.T. Educational Session
7:00 p.m. A.F.S. Technical Session

Tuesday, March 29

- 9:30 a.m. A.W.S. Aircraft and Rocketry
10:00 a.m. ⚙ New Metals in the Petroleum Industry
Morning S.N.T. General Session
2:00 p.m. ⚙ High-Strength Steels
2:00 p.m. A.W.S. Aircraft and Rocketry
Afternoon S.N.T. General Session

Wednesday, March 30

- 9:30 a.m. ⚙ and I.H.E.A. Furnaces for Heat Treating Aluminum and Magnesium
9:30 a.m. A.W.S. Heavy Plate Welding
Morning S.N.T. Ultrasonics
2:00 p.m. ⚙ Powder Metallurgy
2:00 p.m. A.W.S. Welding of Pressure Vessels and Piping
Afternoon S.N.T. Ultrasonics

Thursday, March 31

- 9:30 a.m. ⚙ and I.H.E.A. Heat Treating Furnaces and Equipment
9:30 a.m. A.W.S. Inert-Gas Welding
Morning S.N.T. Radiography
2:00 p.m. ⚙ Metals for the Electronics Industry
2:00 p.m. A.W.S. Inert-Gas Welding
Afternoon S.N.T. Radiography
8:00 p.m. Dinner Dance, Coconut Grove

Friday, April 1

- 10:00 a.m. A.W.S. Brazing and Hard Facing
Morning S.N.T. Magnetics and Penetrants



Technical Program



Monday, March 28

10:00 a.m. — Die Materials and New Forming Methods

Panel Chairman: *Fred M. Arnold*
Chief Process Engineer
Norris-Thermador Corp.

Cast Iron Die Materials

Fred M. Arnold, Norris-Thermador Corp.

Die Materials Applicable to Advanced Airframe Manufacture

Frank J. Pesak, North American Aviation, Inc.

Causes of Toolsteel Failures

George A. Roberts, Vanadium-Alloys Steel Co.

Forming of Stainless Steels

Charles R. Mayne, International Nickel Co.

Selection of Proper Die Materials

Wayne Ewing, Arrowsmith Die & Tool Co.

2:00 p.m. — Today's Titanium Problems and Opportunities

Panel Chairman: *Walter L. Finlay*
Vice-President and Manager of Research,
Rem-Cru Titanium, Inc.

Metallurgical Principles Behind Today's Titanium Problems and Opportunities (Including Heat Treatment Enhancement and New Alloy Possibilities)

R. I. Jaffee, Battelle Memorial Institute

The Latest on Hydrogen and Temperature-Stress Stability

H. Kessler, Titanium Metals Corp.

Aircraft Forgings, Particularly for Airframes

James Russ, Steel Improvement and Forge Co.

Aircraft Fasteners

Thomas E. Spoehr, H. M. Harper Co.

Shop Experience With Airframe Parts

W. T. Kluge, North American Aviation, Inc.

Tuesday, March 29

10:00 a.m. — New Metals in the Petroleum Industry

Panel Chairman: *Claude L. Clark*
Metallurgical Engineer,
Special Steel Developments,
Timken Roller Bearing Co.

High-Strength Steels for Oil and Gas Well Applications

Claude L. Clark, Timken Roller Bearing Co.

Hard Facings and Abrasive Resistant Alloys Used in Oil Drilling

J. R. Spence, Alloy Rod Div., Victor Equipment Co.

New Developments in Materials for Oil Well Pumping Equipment

Edward Green, Axelson Mfg. Co., Div. of U. S. Industries, Inc.

Metals in High-Temperature Applications in the Oil Industry

Alexander P. Maradudin, Standard Oil Co. of California

Corrosion and Embrittlement of Metals for High-Pressure Processing

George Nelson, Shell Oil Co.

2:00 p.m. — High-Strength Steels

Panel Chairman: *A. R. Troiano*
Head, Dept. of Metallurgical Engineering,
Case Institute of Technology

Introductory Discussion of the Problem of High-Strength Steels

P. P. Mozley, Lockheed Aircraft Co.

Static Fatigue and Hydrogen in the Delayed Failure of High-Strength Steels

A. R. Troiano, Case Institute of Technology

Delayed Failures

James O. Huffman, North American Aviation and C. W. Bentley, Douglas Aircraft Co.

Aircraft Requirements at High Strength Levels

Leo Schapiro, Douglas Aircraft Co.

Anisotropy in Heat Treated Forgings

William V. Ward, Lockheed Aircraft Co., Inc.

Initial Yield Phenomena in High-Strength Steels

Morris Cohen, Massachusetts Institute of Technology

Wednesday, March 30

2:00 p.m. — Powder Metallurgy

Panel Chairman: *George A. Roberts*
Vice-President, Technology,
Vanadium-Alloys Steel Co.

Panel Coordinator: *John Q. Adams*
Metallurgical Consultant

Powder Metallurgy for Magnetic Purposes

John Q. Adams, Metallurgical Consultant

High-Strength, High-Temperature Parts and Expansion-Controlled Materials

Pol Duwez, California Institute of Technology

Carbide Cutting Tools

Malcolm F. Judkins, Firth Sterling, Inc.

Powdered Metal Structural Parts

George A. Roberts, Vanadium-Alloys Steel Co.

Powdered Metals for High-Temperature Brazing and Oxidation Resistant Coatings

George Cremer, Solar Aircraft Co.

Thursday, March 31

2:00 p.m. — Metals for the Electronics Industry

Panel Chairman: *D. M. Van Winkle*
Head, Materials Processing Section,
Semi-Conductor Research Laboratory,
Hughes Aircraft Co.

The Metallurgy of Germanium and Silicon Used for Transistors and Diodes

D. M. Van Winkle, Hughes Aircraft Co.

Magnetic Materials for Electron Equipment

C. A. Maynard, Indiana Steel Products Co.

Metals and Materials for Resistors and Capacitors

Arthur E. Middleton, P. R. Mallory Co., Inc.

Application of Special Brazing Alloys and Procedures for Joining Electron Components

A. M. Setapen, Handy & Harman Co.

Joint Program of A.S.M. and Industrial Heating Equipment Association

Wednesday, March 30

**9:30 a.m. — Furnaces for Heat Treating
Aluminum and Magnesium**

Panel Chairman: William J. Parsons

Vice-President, Pacific Scientific Co.

Furnaces for Heat Treating Aluminum and Magnesium
D. W. Pettigrew, Swindell-Dressler Corp.

**Furnaces for Annealing and Billet Heating
Aluminum and Magnesium**

C. B. Kentnor, Jr., W. S. Rockwell Co.

Salt Bath Furnaces for Heat Treating Aluminum

B. P. Planner, A. F. Holden Co.

Induction Heating of Billets

B. E. McArthur, Magnethermic Corp.

**Bright Heat Treatment of Stainless Steel and
Problems Involved in Heat Treating Titanium**

Horace Drever, Drevet Co.

Thursday, March 31

**9:30 a.m. — Heat Treating Furnaces and
Equipment**

Panel Chairman: William J. Parsons

Vice-President, Pacific Scientific Co.

Atmosphere Furnaces

Carl L. Ipsen, Industrial Heating Equipment Association

Salt Baths

Leon B. Rousseau, Ajax Electric Co.

Gas Combustion Theory and Equipment

Arthur B. Wilcox, Eclipse Fuel & Engineering Co.

**Induction Heating and Its Applications
for Surface Hardening and Brazing**

H. B. Osborn, Tocco Div., Ohio Crankshaft Co.

**Induction Heating and Its Application
for Heating for Forging**

Carl P. Bernhardt, Westinghouse Electric Corp.

Program Committee

**Harold H. Block, AiResearch Manufacturing Co.;
Co-Chairman**

**Roy E. Paine, Vernon Works, Aluminum Co. of
America; Co-Chairman**

Claude A. Landusky, Hughes Aircraft Co.

George R. Prescott, C. F. Braun & Co.

L. B. Stark, North American Aviation Co.

John E. Wilson, Climax Molybdenum Co.

A. E. Zezula, Consulting Metallurgical Engineer

F. H. Conaty, McCulloch Motors, Inc.

H. E. Pellett, Pasadena Steel Treating Co.

W. C. Rotsell, Harvey Machine Co.

Ulf Soneson, Jamison Steel Corp.

T. A. Woolsey, Marman Products Co., Inc.

C. M. Campbell, AiResearch Manufacturing Co.

American Welding Society

Monday, March 28

10:00 a.m. — Welding Research

Chairman: Al Penlason

Consolidated Western Steel Corp.

Co-Chairman: James Kerr

C. F. Braun & Co.

Isothermal Studies of Weld-Metal

Microcracking in Mild Steel

Alan E. Flanigan and Z. P. Saperstein, University of California

Triaxial Tensile Stresses in Arc Welded Mild Steel

Harry C. Kennedy and Earl Parker, University of California

Evaluation of Metallic Arc Welds

in Boron-Containing Steels

Ernest R. Telford, Boeing Airplane Co.

2:00 p.m. — Welding of Hardenable Steels

Chairman: Robert Hay

Linde Air Products Co.

Co-Chairman: Arthur Wynn

Harnischfeger Corp.

**A Look at the Automatic Welding
of High-Strength Steels**

W. A. Saylor and R. Roberts, Consolidated Western Steel Corp.

**Characteristics and Properties of Some Low-
Hydrogen Electrodes for Aircraft Application**

D. C. Smith, Harnischfeger Corp.

Metallurgical Aspects of Welding

Precipitation Hardening Stainless Steels

*C. W. Funk, Aerojet-General Corp.,
and M. J. Granger, Wall-Colmonoy Corp.*

Tuesday, March 29

9:30 a.m. — Aircraft and Rocketry

Chairman: Harlan Meredith

North American Aviation

Co-Chairman: Byron Russell

Airline Welding Co.

Fusion Weldability of 24-S-T Aluminum Alloy

John Arthur, North American Aviation

Silver Alloy Brazing of Electrical Connections

Cleon L. Chapen, Gilfillan Bros., Inc.

**Spot Welding of Structural Applications
in Airframe Manufacturing**

Representative of Boeing Airplane Co.

2:00 p.m. — Aircraft and Rocketry

Chairman: Richard Hayes

Douglas Aircraft Co.

Co-Chairman: Francis H. Stevenson

Aerojet-General Corp.

**Titanium Alloy Fusion Weldability
and Correlated Weld Metallurgy**

*Charles W. Handover and Harlan L. Meredith,
North American Aviation*

**New Full-Automatic Weld Tooling
for Aircraft and Missile Joinery**

Byron Russell, Airline Welding Co.

**Metallurgical Aspects of Silver
Brazing Titanium to Titanium**

N. A. Tiner, North American Aviation

Wednesday, March 30

9:30 a.m. — Heavy Plate Welding

Chairman: John Moeller

Pacific Metals Co.

Co-Chairman: John B. McCormick

Lincoln Electric Co.

Heavy Fabrication of Air Hardening Alloy Steels

*M. M. Griffith, Food Machinery & Chemical Corp.,
Ordnance Division*

Low-Hydrogen Electrodes With Iron Powder Additions

Richard K. Lee, Alloy Rods Co.

Welding of Heavy-Walled Alloy Pressure Vessels

Otis Carpenter, Babcock & Wilcox Co.

**2:00 p.m. — Welding of Pressure Vessels
and Piping**

Chairman: Francis McGinley

Victor Equipment Co.

Co-Chairman: Barney David

Arcos Corp.

Hand Welding of 5% and 9% Chromium Steel Pipe

Wm. J. Lester and C. Robert Prescott, C. F. Braun & Co.

Fusion Welding of Pressure Parts of Centrifugal Pumps

Frank Drahos, Byron Jackson Co.

Consumable Backing Ring for Pipe Welding

R. David Thomas, Jr., Arcos Corp.

Thursday, March 31

9:30 a.m. — Inert-Gas Welding

Chairman: H. W. Hiemke

California Alloy Products Co.

Co-Chairman: David Elmer

C. F. Braun & Co.

New Inert-Arc Welding Process for Mild Steel

Harry Bichsel, Westinghouse Electric Corp.

Inert-Gas Welding of Stator Packs

F. J. Pilia, Linde Air Products Co.

Tooling for Mechanized Fusion Welding

of Thin-Gage Materials

Representative of Boeing Airplane Co.

2:00 p.m. — Inert-Gas Welding

Chairman: Charles B. Robinson

Air Reduction Pacific Co.

Co-Chairman: Charles Johnson

Victor Equipment Co.

New Developments in Inert-Gas Welding

John H. Berryman, Air Reduction Sales Co.

Inert-Gas Welding of Titanium

A. V. Levy and Robert Wickham, Marquardt Aircraft Co.

New Techniques in Inert-Gas Shielded Metal-Arc Welding

R. W. Tuthill, General Electric Co.

Friday, April 1

10:00 a.m. — Brazing and Hard Facing

Chairman: George Griffin

Victor Equipment Co.

Co-Chairman: Alex Maradudin

Standard Oil Co. of California

Silver Brazing of Refractory Metals

C. H. Chatfield and John Ross, Handy & Harman Co.

High-Temperature Alloy Brazing

George C. Driscoll, Western Alloy Engineering Co.

Hard Facing of Oil Well Drill Pipe

Otis Cullum, Bakersfield, California

A.W.S. Program Committee

Hugo W. Hiemke, California Alloy Products Co.;

Chairman

Robert Hay, Linde Air Products Co.

Richard Hayes, Douglas Aircraft Co.

Harlan Meredith, North American Aviation Co.

Francis McGinley, Victor Equipment Co.

A.W.S. Program Supervisors

Arnold Jensen, Pacific Metals Company; Monday sessions

Leo West, Douglas Aircraft Co.; Tuesday sessions

Warren Vetter, Southwest Welding & Mfg. Co.;

Wednesday sessions

Bob Conkling, Linde Air Products Co.; Thursday sessions

Frank Tucker, Victor Equipment Co.; Friday session

Society for Nondestructive Testing

Monday, March 28

Morning — Educational Session

Chairman: Robert G. Strother

*Manager, Western District,
Magnaflux Corp.*

Co-Chairman: Dan O'Halloran

Northrup Aircraft, Inc.

Orientation

Harry O. Williams, Douglas Aircraft Co.

Ultrasonics

Rod Kleint, North American Aviation

X-Ray and Fluoroscopic Inspection

Robert Reynolds, Lockheed Aircraft Corp.

Afternoon — Educational Session

Magnetic Particle Inspection

Stan Sorenson, Northrup Aircraft, Inc.

Penetrants

J. Rutledge, McDonnell Aircraft

Evaluation of Indications

A. S. Billings, Ryan Aeronautical Co.

Technical Report

C. E. Van Hagan, U. S. Naval Ordnance Test Station

Tuesday, March 29

Morning — General Session

Welcoming Address: W. C. Hitt,

Douglas Aircraft Co., Inc.

National President, Society for Nondestructive Testing

Chairman: Clifford W. Mell

Lockheed Missile System Division

Co-Chairman: Daniel Rosenthal

Professor of Engineering,

University of California

How Deep Is That Crack? *H. N. Staats, Magnaflux Corp.*

**The Use of Nondestructive Test Methods in the Largest
Electrical Manufacturing Plant in the West**

Wallace J. Erichsen, Westinghouse Electric Corp.

High-Speed Motion Pictures

Lester McIntosh, Eastman Kodak Co.

**Use of Nondestructive Testing
on Southern Pacific Railroad**

Arthur S. Pedrick, South Pacific Co.

Tuesday Afternoon — General Session

Chairman: Roy E. Paine

Works Chief Metallurgist,
Aluminum Co. of America

Co-Chairman: Leslie E. Ball

Wyle Laboratories

Bearing Tester

E. M. Baker, Baker Co., Inc.

High-Temperature Brittle Coatings
for Experimental Stress Analysis

H. J. Jackson, California State Polytechnic College

A New Inspection Tool—Measures Embrittlement
and Erosion in Aircraft Exhaust Systems

Justin J. Shapiro, American Instrument Co.

Leak Detector

W. H. Pappin, Knolls Atomic Power Laboratory,
General Electric Co.

Wednesday, March 30

Morning — Ultrasonics Session

Chairman: Rebecca H. Sparling

Design Specialist, Metallurgy and Processing,
Convair

Co-Chairman: Al Barath

Nondestructive Testing Laboratory,
Douglas Aircraft Co.

Ultrasonic Applications in the Aluminum Industry

William L. Fink, Aluminum Co. of America

The Correlation of Ultrasonic Indications, Defects
and Metallurgical Properties in 2½-In. 75 S Plate

A. P. Binsacca, Northrop Aircraft, Inc.

Ultrasonic Flaw Plotting Equipment

R. W. Buchanan and C. H. Hastings, Watertown Arsenal

Grain Size Determinations by Ultrasonics

Nicholas Grossman, Atomic Energy Div.,
Sylvania Electric Products, Inc.

Afternoon — Ultrasonics Session

Chairman: G. M. Taylor

Los Alamos, N.M.

Co-Chairman: Langford L. Brown

Chief Inspector, Rohr Aircraft Corp.

Ultrasonic Attenuation in Metals

Rohn Truell, Brown University

Direction of Flaws in Jet Engine

Parts Determined by Ultrasonics

Merv Bratt and Vernon Wiegand, General Electric Co.

Industrial Application of Contact Scanning

Ed Pringle, Sperry Products, Inc.

Ultrasonic Inspection of Jet Engine

Compressor and Turbine Wheels

Don Erdman, Electro-Circuits, Inc.

American Foundrymen's Society Los Angeles Chapter

Monday, March 28, 7:00 p.m.

An Engineering Appraisal of the
Investment Casting Process

Demeter Giza and James B. Price, Jr.,
Arwood Precision Casting Corp.

Ductile Iron and Its Applications

Morris Asimow, Enterprise Ductile Iron Foundry, Inc.

What Shell Molding Offers to the

Producer and the User of Castings

Walter H. Dunn, Solar Aircraft Co.

METAL PROGRESS; PAGE 76

Thursday, March 31

Morning — Radiographic Session

Chairman: James W. Dutli

Los Alamos, N.M.

Co-Chairman: Merrill Peterson

Rheem Manufacturing Co.

Training of Radiographers

W. Havercroft, Department of Mines and
Technical Surveys, Ottawa

Measuring Coating Thickness by Auto-Radiography

Warren McGonnagle, Argonne National Laboratory

Modern Fluoroscopic Practices

W. R. Hampe, Westinghouse Electric Corp.

Intensification of Radiographs

Emery Meschter, Photo Products Div., DuPont & Co.

Afternoon — Radiographic Session

Chairman: W. J. Erichsen

Westinghouse Electric Corp.

Co-Chairman: J. Schneeman

X-Ray Products Corp.

Available Isotopes for Industrial Radiography

Gordon L. Locher, Western Radiation Laboratory

Techniques for Super-Voltage X-Ray

E. Alfred Burrill, High Voltage Engineering Corp.

An Introduction to Xeroradiography

Robert Vyverberg, Haloid Corp.

Field Evaluation of Xeroradiography

G. M. Taylor, Los Alamos Scientific Laboratory

Friday, April 1

Morning — Magnetic and Penetrants Session

Chairman: C. E. Klein

Process Engineer, Convair

Co-Chairman: Clyde O. Penney

Metallurgist, Denver & Rio Grande Railroad Co.

Magnetic Particle Inspection

I. Dagan, Rohr Aircraft Corp.

Dye Penetrants and Post Emulsifier

Fred Rohde, Westinghouse Electric Corp.

Process Control by Magnetic Particle
and Penetrant Inspection

E. S. Barnhart, Solar Aircraft Corp.

Interpretation and Evaluation of Magnetic

Particle and Penetrant Indications

B. R. Swarts, Convair

S.N.T. Program Committee

Maurice J. Curtis, Materials Evaluation Branch,
U.S. Naval Ordnance Test Station; **Chairman**
R. E. Reynolds, Lockheed Aircraft; **Co-Chairman**

A.F.S. Program Committee

S. L. Jackson, Electro Metallurgical Co.; **Chairman**

I.H.E.A. Program Committee

A. E. Tarr, Leeds and Northrup Co., **Chairman**

Cooperating Societies Chairman, Los Angeles Chapter

Edgar C. Buckingham, Field Service Engineer,
Pacific Scientific Co.

Mass Production of Sheet Magnesium

By G. ANSEL*

Magnesium sheet and plate in unprecedented widths and lengths is being provided for industrial fabricators by Dow Chemical Co.'s new plant in Madison, Ill. In addition to being the largest mill ever built for magnesium, the plant has a modern continuous casting unit and is also able to furnish extrusions and alloy ingots.

FOR THE first time in the history of the magnesium industry, sheet and plate, either flat or in coils, weighing up to 2000 lb., is being produced commercially; plate can be finished up to 72 in. wide and 24 ft. long. This is being done at the new Madison, Ill., plant of the Dow Chemical Co., where primary magnesium is alloyed, cast, and then fabricated into mill products. The new mill, all under one roof, also makes a full range of magnesium extrusions and alloy ingots. It is thus almost a fully integrated unit. (Primary magnesium is transported by barge and rail from company plants in Texas.)

Plant History — Dow Chemical Co. expanded

the alloy plant, extrusion plant and rolling mill for magnesium at Midland, Mich., between 1940 and 1942. During World War II the entire production of these plants was reserved for military use. At war's end much of the sheet was diverted into such uses as materials handling, tread plate, pattern plate, and photo-engraving plate.

The feasibility of rolling magnesium on a modern mill was demonstrated successfully for the first time in 1946 at the plant of the American Rolling Mill Co., at Butler, Pa. (the original tandem mill in the United States). Dow pro-

*Technical Director, Madison Div., Dow Chemical Co., Madison, Ill.

provided 800-lb. ingots which were broken down on the reversing hot mill, passed directly to the 4-stand tandem, reduced to 0.064 in., and coiled at 1200 ft. per min., the entire operation being completed in 4 min. The advantages of edge rolling were demonstrated at the same time, and the results indicated that any significant expansion of sheet rolling capacity should be built around this coil rolling process.

By January 1949 it became evident that more magnesium rolling capacity would be needed in the United States for the enlarged defense program. An increase in sheet rolling capacity from the conven-

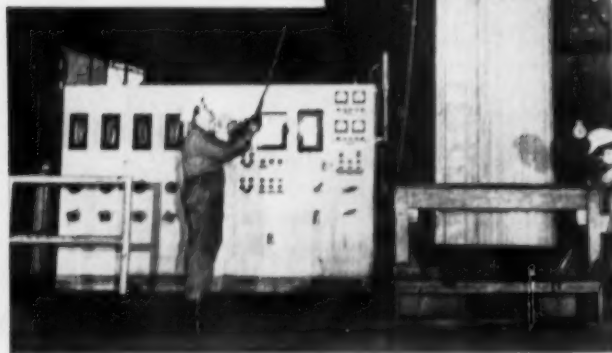


Fig. 1 — Dummy Block of Appropriate Magnesium Alloy Being Lowered Into Position to Start Continuous Casting of New Ingot. Control panel for casting machine at left. Casting pot is at right (not shown)

cated on May 26, 1954 (see "Critical Points", *Metal Progress*, August 1954, p. 104).

Melting and Casting — The primary function of the alloy plant is to provide rolling and extrusion ingots to feed the mills and presses. Production of magnesium alloy ingots for sale is a secondary but by no means small operation.

Melting and casting are done in three types of equipment. First is a conventional magnesium melting and alloying unit, terminating in a machine for casting foundry ingots. Second is an experimental intermittent casting unit for experimental alloys and for odd shapes and sizes of extrusion ingots. The third, which will be described in some detail, is a group of continuous casting units for round extrusion ingots and rectangular rolling ingots.

For continuous, direct, chill-casting, ten melting and alloying pots are arranged in two groups of four with two casting pots in line with the mold. The pots are of cast steel holding 5000 lb. of magnesium and set in gas-fired furnaces lined with firebrick. Melting temperatures and pot temperatures are regulated automatically by means of thermocouples.

Primary magnesium and plant run-around scrap are melted down in the first line of pots. After analysis the necessary alloying ingredients are added and the metal is pumped to the holding pots where it is held at temperature for the specified time to obtain thorough diffusion. From the holding pots the metal is pumped into the casting pots. (Because molten magnesium does not alloy with iron or steel it can be transferred almost as readily as water through steel pipes using air-driven pumps.)

The entire casting unit comprises a complex device developed after extensive studies by the Dow Chemical Co.'s technical and engineering staff. Molten metal from the last pouring pot is

tional 100-lb. ingots to 1-ton rolling ingots presented a number of challenging problems. Basically, larger facilities would be needed as well as coil rolling equipment and a plant closer to raw materials and markets.

Preliminary surveys of markets and available plant sites were undertaken, and by March 1950 a proposal was adopted by management for an integrated rolling mill and extrusion plant at Madison, Ill., to replace the Midland facilities in Michigan. Rehabilitation of existing extensive buildings and new construction were started in March 1951 on the site of an obsolete tank armor factory. The new plant was dedi-



Fig. 2—Rectangular Rolling Ingot Is Cut to Desired Length by Automatic Saw Traveling at Same Speed as the Continuous Cast

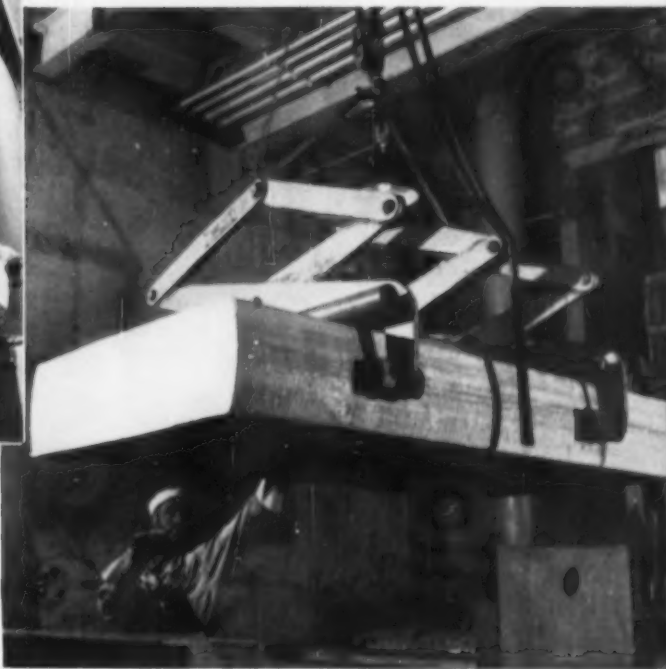


Fig. 3—Slab Ingot Being Hoisted Out of Casting Pit, Enroute to Milling Machine Where Entire Surface Will Be Scalped

pumped into a bottomless sleeve mold made of copper. (A dummy block of the same alloy and size of ingot being cast had previously been inserted into the mold and gripped by rollers below, so the new metal is cast on top; see Fig. 2.)

Water jets cool the mold so that a strong external shell of metal has solidified by the time the new casting has traveled from the liquid line to the bottom of the mold. As the metal solidifies throughout its cross section the cast descends. At a predetermined point, some 40 ft. below the pouring floor, an automatic saw, actuated by a photoelectric cell, cuts off the ingot

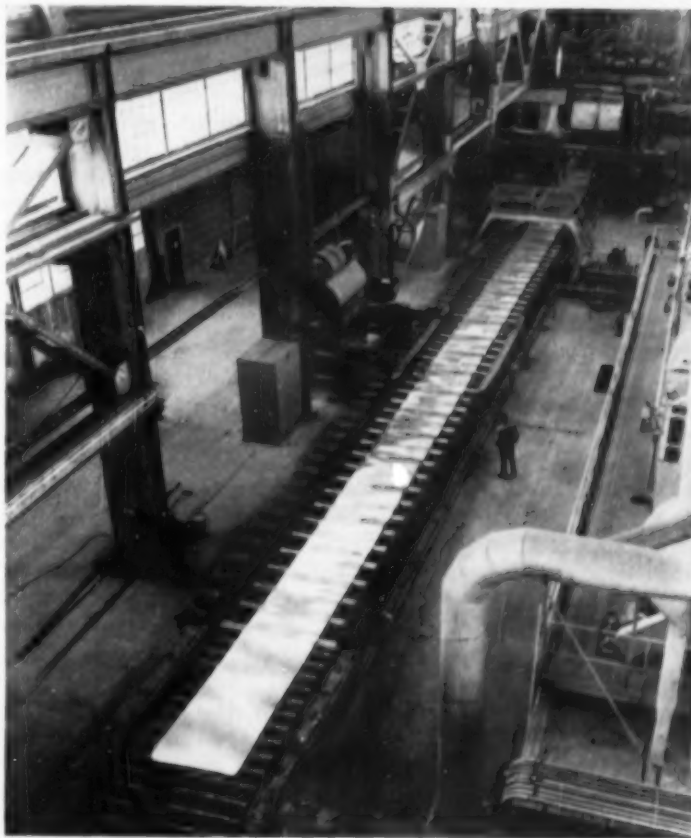


Fig. 4—The 84-In. Reversing Coil Mill Is the Largest High-Speed High-Production Rolling Mill Ever Built for Magnesium. At right is one of the lengthy furnaces or ovens for heating the metal to rolling temperatures



Fig. 5—5500-Ton Extrusion Press for Magnesium. Round billets and three-stage induction heating units at left

at the proper length. The "flying saw" mechanism moves down at the same rate as the cast, and when the cut is completed the saw returns up to its original position.

The ingots, now measuring up to $11 \times 41 \times 76$ in. are returned by elevator to the main floor, where surface roughness and impurities are removed in a large face miller.

Rolling—As is well known, magnesium, because of its hexagonal crystallographic structure, is best deformed hot, so the ingots are conveyed at a constant rate through gas-fired furnaces or ovens to bring them up to a rolling temperature of 800°F . The ovens are automatically controlled and temperatures checked constantly to insure uniformity necessary for top quality.

The heart of the new rolling process is the 84-in. reversing hot mill, designed and built by United Engineering & Foundry Co. especially for magnesium. Rolling is controlled from a single pulpit either by manual controls or an electric program board which automatically sets reductions for each pass at speeds up to 1100 ft. per min. The rolled plate is either fed into a flying shear for flat plate or coiled for further reduction on an 84-in. finishing mill.


The coils or flat plates are annealed at 650°F . Finishing operations are carried out over a range of temperatures varying from room to 600°F ., depending upon desired reduction, final tensile properties, hardness and finish. Production sheet is rolled down to 0.072-in. gage on the 84-in. finishing mill. Smaller strip and coil mills are used to make thinner magnesium sheet for aircraft and some other uses.

Extrusion—The extrusion process as installed at Madison has not been changed significantly over that originally used at the Midland plant. One improvement is the installation of induction heating; much modern materials handling equipment and facilities maintain better tolerances and dimensional characteristics.

In 1952, however, a contract was signed with the Defense Dept., U.S.A., for the installation at Madison of a 13,200-ton extrusion press made by Hydraulik in Germany. Since then certain modifications have been incorporated to make this the largest, most modern press for light metals in the United States. The press is scheduled for completion in 1955 and will be capable of producing larger and longer magnesium shapes than have hitherto been available.

Applications—The largest field of application for the wider and longer sheet plate produced at Madison will continue to be the various phases of the transportation industry; aircraft will be the largest consumer of thin-gage sheet. Highway transportation, including truck bodies and van trailers, represents an increasingly important market for magnesium sheet in the thicker gages.

Development of the new rapid etching process for magnesium photo-engraving, along with extended use in the older engraving and printing processes, will consume much of the sheet.

The greatest portion of the magnesium plate produced goes into materials handling in the form of tread plate. Magnesium tooling plate for jigs and fixtures is now being offered to industry, and is expected to grow into a large segment of the plate production. 

Fiber Metallurgy

By A. G. METCALFE, C. H. SUMP and W. C. TROY*

When metal fibers or filaments are used as raw materials for compacting and sintering a finished part, bodies with novel properties may be prepared. A large range of porosities is possible, combined with high strength and toughness.

EARLY IN 1948, a somewhat unusual departure from ordinary metallurgy aided in making a filter of high porosity. Techniques were similar to those of powder metallurgy but, instead of powder, short metal fibers were compacted. The versatility of the method appears to be more important than the fact that it yielded an effective filter—indeed, it could lead to an entirely new use of metals.

Many of the operations are the same as for powder metallurgy. There is one fundamental difference—metal fibers have continuity in one direction. Thus, they may be viewed as a transition between the particles used in powder metallurgy and the sheets used in laminated structures. Fiber metal bodies should be made at the high production rates of powder metal parts, but they also should lend themselves to felting processes similar to the Fourdrinier process used in paper making. Economically, it has been found that metal fiber costs can be competitive with metal powders. There are expectations that the fiber metal body would have stronger metallic bonds, for preliminary examinations showed their tensile and impact properties to be superior to the all-powder sintered compact.

Powder Versus Fiber Bodies—Effective bonding is a prime essential in powder metal bodies and has been responsible for much work in this field for many years. For example, areas of contact between the particles are limited; irregular particle surfaces may be responsible for voids in the finished body. The fabricator improves the bond strengths by such expedients as high compacting pressures, high sintering temperatures, coining operations and liquid-phase sintering. The use of a metal fiber will avoid some unusually drastic treatments because bonding along the length of the fiber already is at a maximum.

The idealized structure of a fiber metal body (Fig. 1) illustrates the superior interior keying.

After pressing, an additional contribution to the strength is obtained from mechanical interlocking (Fig. 2), which can be augmented by kinking the original fiber. (This is particularly useful in highly porous materials compacted under light pressure.) Mechanical interlocking during pressing gives a high "green strength", and highly porous bodies may be manipulated with surprising safety.

The difference in bonding between fiber and powder bodies is illustrated for the idealized cases in Fig. 1 and 3. Figure 3 represents an ideal body composed of spherical particles; its porosity is 47.6% before pressing. In the idealized case, there is no systematic mechanical bonding evident in the body after pressing.

This difference of structure results in a notable difference in body continuity: During oxidation of nearly dense molybdenum-ceramics, the powder bodies fail rapidly due to the combined effects of oxidation and rupture of the bonds. In metal-ceramic bodies formed from molybdenum fibers, high-temperature damage progressed along a flat interface rather than by a three-dimensional disintegration.

Tests have been made to compare tensile and impact strength, and have shown that the fiber metal body has significant advantages. Particularly at higher porosities, a fiber metal body has superior tensile strength:

TENSILE STRENGTH	POROSITY OF BODY	
	POWDER IRON	FIBER IRON
7,500 psi.	32%	50%
11,000	29	40
15,000	23	30

Compacting and sintering conditions were adjusted to achieve the above porosities, and it is

*Dr. Metcalfe is research metallurgist, Mr. Sump is supervisor, and Mr. Troy is assistant manager, metals research, Armour Research Foundation of Illinois Institute of Technology.

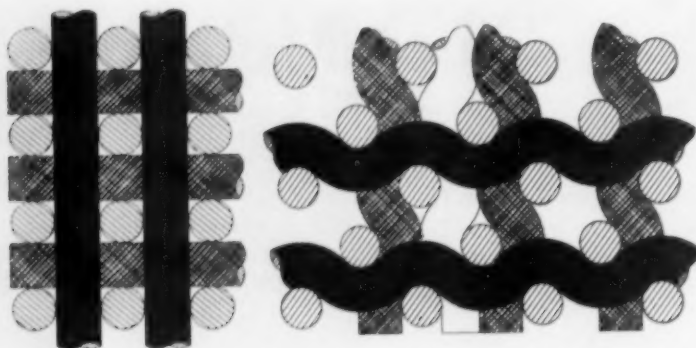


Fig. 1 (Left) — Idealized Orthogonal Structure of Fiber Metal Body Before Pressing. Sintering attaches each fiber to many other neighboring fibers. Fig. 2 (Right) — Idealized Structure, Mechanically Interlocked by Pressing or by Kinking. Three different levels of fibers are shown. Each fiber is bonded to several hundred others after pressing and sintering

not known whether these conditions were optimum for either powder or fiber materials.

Iron compacts were markedly superior in impact when fiber metal was used. Figure 4 shows a comparison of the unnotched bars, 0.490 by 0.200 in., broken in a 25 ft-lb. Baldwin Sonntag impact testing machine.

Table I gives the numerical values, both obtained and extrapolated, and Fig. 4 shows the types of fracture. The strengthening effect of the metal fiber addition to a powder body is well illustrated. It is also interesting to note that the fiber bodies have not failed completely; the two halves still are held together by unbroken fibers. Since long fibers were used for these test pieces, it is obvious that failure occurred largely through the fibers rather than through the bonds. This strengthening effect could be important in parts where brittle and catastrophic failure must be avoided.

Fiber Metallurgy Processes — The properties of fiber metal bodies can be adjusted by controlling the methods of manufacture. For example, the selection of the proper wire diameter and length can be quite important in developing optimum properties, just as powder parameters affect the mechanical properties of the powder metal product.

After determining the proper size and diam-

eter, the fiber orientation should be considered. Should there be preferred orientation or random distribution? In other words, are directional properties desired? Hydrostatic (three-dimensional) pressing minimizes directional properties; compaction between press platens will obviously accentuate directionality.

Another consideration is the character of the fiber surface. Sometimes it is desirable to have it rough, with tiny barb-like projections to assist mechanical interlock, and strengthen low-density bodies. Further interlocking results from a controlled kinking of the fibers, although this expedient may impair the flow of the fibers during compaction.

Addition agents promote superior bonds at points where the fibers come in contact. One example is the use of copper to braze iron fibers; another is controlled reduction reactions during sintering. Additions to the fibers can be made by coating and sheathing techniques, such as electrodeposition or cable coating.

A review of possible manufacturing techniques shows that fibers can be used in processes that extend beyond those employed by powder metallurgy. Mention should be made, however, of several that do apply specifically to fiber material. These bodies can be cold pressed unidirectionally in standard presses if considera-

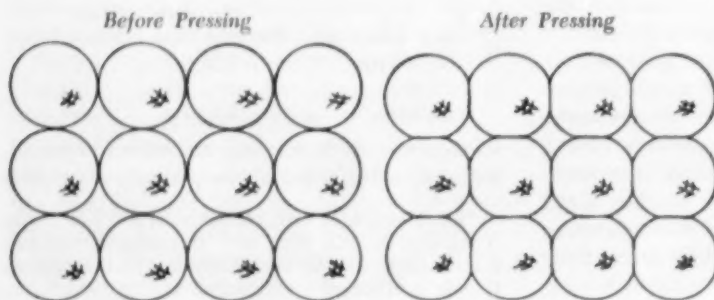


Fig. 3 — Idealized Packing of Spherical Powder Particles Before and After Pressing. Note the lack of mechanical interlock between particles before pressing; each particle is bonded to a maximum of six neighbors after pressing and sintering

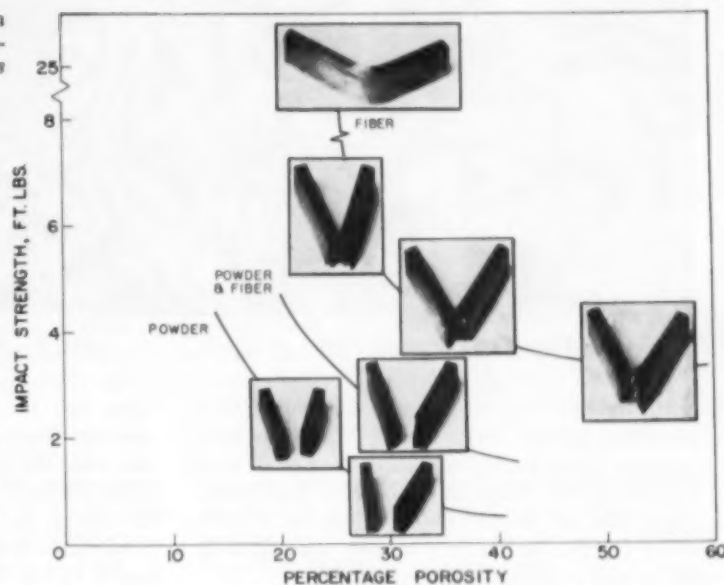
Fig. 4—Effect of Porosity on the Impact Strength and Fracture of Porous Iron Bodies

tion is given to the filling of the die, flow characteristics, apparent density, and so on. Where required, hydrostatic compaction will help avoid directionality in fiber orientation. Some recent experimental rolling of powder directly into sheet may be extended to the use of metal fibers as well; in this way the rolls would compact the fibers and lead to a preferred orientation in the sheet.

Optimum temperature and time of sintering may be quite different from those used for powder bodies. (Atmospheres may be unchanged.) Pressure sintering, a technique employed for friction materials, is sometimes useful.

Filters—Fiber felting techniques appear to offer promise of a process inherently having a high production potential. The Fourdrinier paper-making process resembles the rolling together of metal fibers to produce porous sheet. This resemblance suggested a technique used in early experimental production of filter material. Porosities as high as 90% were required, necessitating a radical departure from previous manufacturing methods—namely, low-pressure compaction and then sintering of carefully graded spherical particles. Since particles are in point-contact, and the contact area is increased somewhat by sintering, a theoretical limitation of about 47% porosity exists (Fig. 3).

The use of felted metal fibers overcame the problem of limited porosity. The fibers were processed to the optimum length and diameter and suspended in a suitable liquid vehicle. This suspension was then transferred to an aspirated



filter yielding a mat with the metal fibers intimately interwoven.

After drying, the felted material could be processed in various ways. It could be pressed to a higher density. In others, a brazing metal such as copper could be added to improve the strength and ductility after a suitable heat treatment. Could no other metal or alloy addition be tolerated, sintering alone would bond the fibers at points of contact. (These points of contact are as small as in powder metal compacts, but strength is increased because of the hundredfold increase in the number of the bonds and the mechanical interlocking; the latter, of course, may be increased by suitable preparation of the fibers.)

Figures 5 and 6 on the next page illustrate the similarity in the structure of filter paper and of metal fiber filter bodies.

Potentialities of Fiber Metallurgy—One general field of potential use for fiber materials is for high-strength, high-porosity bodies. Filter materials represent only one of the fields; use can be made of their high stiffness-to-mass ratio compared to other bodies.

Applications have been proposed in the aeronautical field. The higher ratio of strength-to-porosity, compared with porous powder metal bodies, favors its use as part of the air-foil—for example, in the de-icing systems now using porous metals to distribute the de-icing compound uniformly over the wing edge. Another such use might be in "boundary layer" control, in which the movement of air through the wing

Table I—Comparative Impact Properties of Iron Bodies

IMPACT STRENGTH	POROSITY		
	ALL POWDER	MIXTURE	ALL FIBER
1 ft.-lb.	30	—	85*
2	22	35	70*
4	17*	—	45
6	—	—	27
Over 25	—	—	18†

*Extrapolated value.

†Specimen did not break.

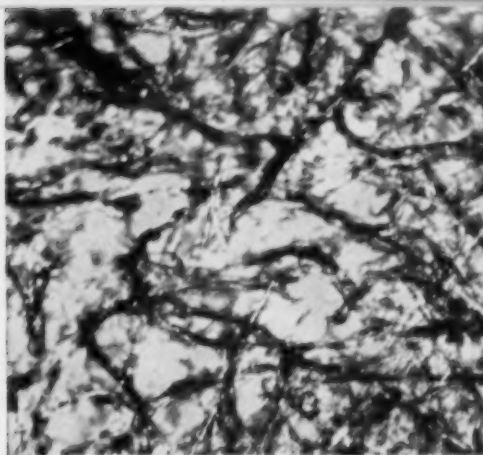


Fig. 5 — Filter Paper Showing Fibers. 75×

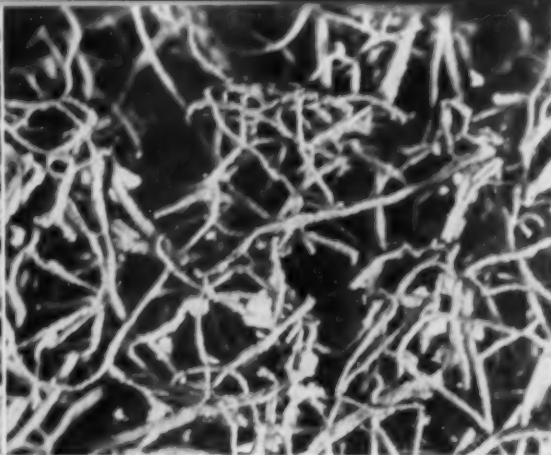


Fig. 6 — Metal Fiber Body. 75×

surface is used to preserve streamline flow giving increased lift and reduced drag.* Another such use may be for transpirational cooling of air-foils to reduce the temperatures during high-speed flight. This can be very high at the speed of 3000 miles per hr., as reached by the German V-2; the temperature rise is 1500° F.

Metal fibers can be prepared as skeletons to support materials of lesser strength. Such additions would include plastics, active catalyst masses, active battery masses, and friction materials.

Use of fiber metal bodies at high temperatures may follow four lines of development toward the following general applications:

1. An increase in the impact strength of powder metal products, such as bonded refractory hard metals and metal-ceramic combinations, by the incorporation of fibers.
2. An increase in the softening temperature of bonded refractory hard metals by the incorporation of refractory metal fibers.
3. Use of porous fiber bodies to permit higher ambient temperatures by the application of transpiration cooling.
4. Use of less strategic materials at the present temperatures by the application of transpirational cooling.

One serious drawback of some of the present metal-ceramic materials is poor impact strength. No experimental work has been performed to confirm this point, but it is believed that the incorporation of fibers in the structure may help this situation. An increase in the impact strength of a powder metallurgical body by the incorporation of fibers has been demonstrated by us — see Table I. Certain limitations to this technique can be foreseen in liquid-phase sintering, but

these may be overcome by suitable fibers and powders. Incorporation of suitable metal fibers may raise the softening temperature, particularly when the bond consists of one of the less refractory metals such as nickel.

Adequate transpiration cooling awaits porous metal bodies with adequate properties. For example, in the gas turbine the weight and complexity of the required additional equipment must be offset by improved performance, and porous fiber materials can achieve the desired combination of properties more nearly than other porous materials. We have seen a recent communication from D. G. Ainley of National Gas Turbine Establishment, England, to A. G. Metcalfe, saying that internally cooled blades made from Vitallium powder have been operated at 2000° F. for several hours. For the same life of the blades, the operating temperature could be increased 500° F. when 2% of the air was used for cooling. It is likely that transpiration cooling would be more efficient than internal cooling and would enable the engine to operate at greater efficiencies as well.

From another viewpoint, if transpiration cooling were used at present jet-engine temperatures, they could be built of less strategic materials such as stainless steel fiber. This would become of great importance in a national emergency.

Another property of fiber metal bodies has been considered for further study, namely, their ability to conform to an irregular surface without extensive plastic flow and permanent deformation. This is enhanced if the fiber retains a high yield strength so that small adjustments of the contour involve only an elastic movement.

Conclusion — Doubtless the techniques outlined above can be considerably extended. As this method of forming engineering materials is so new, undiscovered improvements await further investigation and commercialization. ☐

*See "1954—Big Year for Boundary Layer Control", by H. D. Fowler, *American Aviation*, March 15, 1954, p. 20.

Metallurgy and Stratospheric Flight

By Major P. L. TEED*

Materials for airframes of subsonic crafts are both abundant and various, and with some tinkering of their composition most are suitable for crafts flying at speeds up to 1400 miles per hour; beyond this speed, titanium, steel or totally new structural materials will have to be used.

PROBLEMS are the inevitable consequence of change in conditions. Nearly four decades after that great landmark in human history, the Kitty Hawk flight, airplanes began regularly to enter the stratosphere. New and surprising problems inevitably and sometimes dramatically arose, for a new environment was being experienced. The purpose of this note is to examine some of the metallurgical perplexities which thereby came into being.

Since stratosphere is not "familiar in our mouths as household words", something must be said of the characteristics of this portion of our atmosphere; otherwise it would indeed be as useless to describe the metallurgical consequences of stratospheric flight without disclosure of their causes as it would be to give a dissertation on drunkenness without saying something about drink.

Meteorologists have divided into zones the atmosphere surrounding the world of our being. To describe their achievement the weathermen invented three words, troposphere, tropopause and stratosphere. But two of these, troposphere and stratosphere, would have been adequate.

This splitting of space by words has been justified by the observed height-temperature relationship of the atmosphere. In the world in which we can climb on our feet, the temperature of the air decreases with height; meaning that, as we sweat under summer's heat in the lowlands, snow in all its crystal crispness may be lying on the cool distant mountains. The portion of the atmosphere in direct contact with the earth is called the troposphere by the meteorologists. Here man has lived from time immemorial. To the zone above this, they have given the name, stratosphere. This is characterized by an ex-

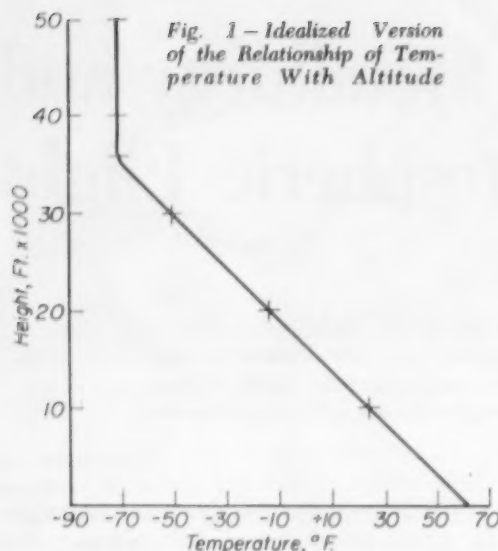
remely small change in temperature with height. So far, so good; with verbal profligacy, the meteorologists have called the two-dimensional layer between these the tropopause. "Boundary" would have sufficed.

In a few sentences, having reached in thought what man has taken a million years to reach in fact, it is appropriate to examine the physical and chemical characteristics of the zone now entered. Were these not different from those with which all are normally familiar, there would be no problems of stratospheric flight. Figure 1 shows a graph by the International Committee for Air Navigation (ICAN) that gives the average relationship of temperature with height over western Europe. The tropopause (boundary) is shown at a height of 35,000 ft. (6.6 miles). Here the stratosphere starts and, as is clearly illustrated by the curve, the temperature of such air as exists up to 50,000 ft. (and it is now believed up to about 90,000 ft. or 17 miles) does not appreciably change. In this range it is normally -69.7°F .

The curve in Fig. 1 is an idealized one. It is the achievement of a committee which, for the sake of international concord, has presumably been forced to depart more than somewhat from reality. Figure 2 shows the actual relationships of temperature with height during 69 flights in summertime over the south of England. The tropopause, it will be seen, was once as low as 25,000 ft. and once as high as 37,000. Further, the temperature of the stratosphere ranged from -54°F . to -90°F .

Turning from England (which is so much smaller than Texas) to the world (which non-

*Deputy Chief of Research and Development, Vickers-Armstrongs Ltd., Weybridge, England



Texans regard as being appreciably larger) there is evidence that, over the poles, the stratosphere is generally at a height of 24,000 ft. and something like 65,000 at the equator. Furthermore at the equator the high-altitude temperature is usually lower than in high latitudes. This seeming paradox is nevertheless satisfactorily explicable on the basis of quite mundane physics. The fact, however, remains that in India stratospheric temperatures of -130° F. (or even slightly lower) have been recorded.

Figure 3 discloses two other characteristics of the atmosphere. Both its pressure and its density decrease continuously with height. Unlike with temperature, there is no abrupt change in the slope of the curves at the tropopause—they are as unperturbed by the boundary as a mean man is by the importunities of a blind beggar. Figure 4 is very different. It indicates something dramatic. It shows how, above the tropopause, the humidity of the atmosphere changes—in summer at 30,000 ft. in the south of England, the relative humidity is about 42%, yet, with an increase in height of only 10,000 ft., it falls to a mere 2%.

By means of graphical illustrations, the relationship of height with temperature, pressure, density and relative humidity has been recounted for the purpose of disclosing the strange and even remarkable conditions prevailing in the stratosphere. This creates two pertinent questions: Can we fly in air, colder than the poles themselves, thinner than the most improbable story ever told from the witness-stand and drier, far drier than the nonalcoholic State of Kansas?

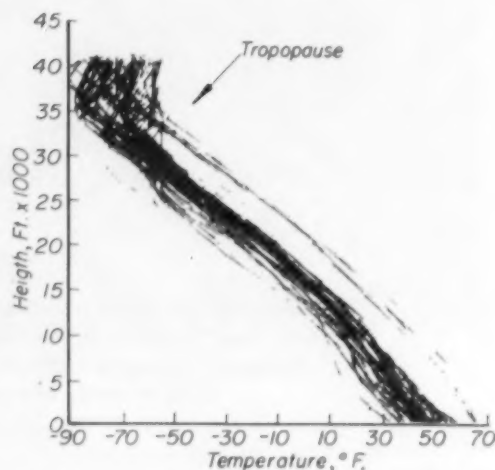
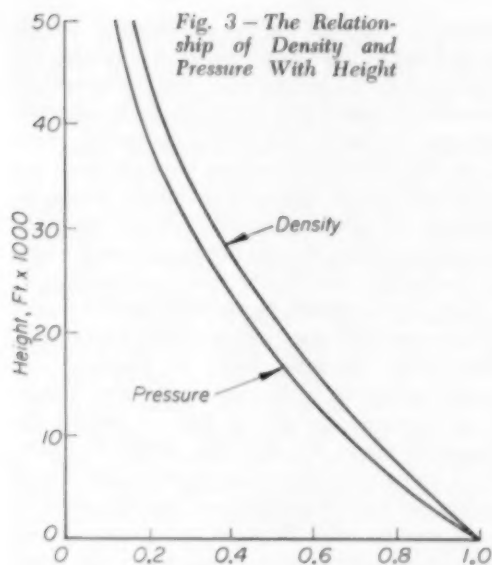


Fig. 2 - Chart Showing Variation of Temperature With Height for 69 Ascents to 40,000 Ft.

The second is: Do we want to do so? The answer to the first is an emphatic "Yes"; to the second it is an affirmative by the majority. (The reader may feel that his views are adequately expressed by the famous but probably apocryphal phrase of Sam Goldwyn, "Please include me out.") Civilized governments—those prepared to go to war to remain civilized—and airline operators who know that their stockholders will declare worse than war on them if there is no dividend, recognize the technical and economic necessity of stratospheric flight.

The case for such flight is disclosed in Figure 5. Now a large part of the resistance or drag of an airplane is proportional to the density of the ambient air. As has already been pointed out, density falls with height. So too does the jet thrust, but fuel consumption per hour is roughly proportional to jet thrust. Therefore, at great heights, operational costs decrease and maximum range increases. To take a concrete example, a present-day high subsonic aircraft flying at about 40,000 ft. requires only one-third the fuel it would at the same speed at ground level.

Taking the case for stratospheric flight as proven, we may now ask, "What additional problems are imposed on the metallurgist?" One would like to give a brief, clear-cut answer. This is, however, comparable in difficulty to replying "Yes" or "No" to the question "Have you left off beating your wife?" It all depends on the *speed* at which we fly in the stratosphere. The military, completely unfettered by economic considerations and well versed in loudly demanding incompatibles, call for aircraft capable of flying



at the highest speed for the greatest distance. Airline operators, with better understanding of the mechanics of flight, base their requirements on economic considerations.

At the present state and in the near future state of the art, aircraft will be capable of hovering flight at subsonic speeds (the velocity of sound at ground level is about 760 miles an hour and, in the stratosphere, 660) and at low altitude; they are therefore outside the ambit of this survey. Medium-range transports will be limited to subsonic speeds, but will sometimes be at stratospheric heights. Fighters, reconnaissance machines, long-range transports and bombers will fly at supersonic speeds at stratospheric heights. Subsonic civil aircraft will long be employed over considerable areas of the world like western Europe, with its population of about 280,000,000, its density of population of over 200 to the square mile and its relatively short intercity distances. Such machines, while perhaps not entering the stratosphere, will be flying at heights at which the ambient air will be but little warmer than that above the tropopause. This writer believes that supersonic stratospheric airplanes will be the order of the day for intercontinental and nonstop stratospheric routes within the next decade.

From the metallurgical standpoint, the problem of stratospheric flight resolves itself into two parts. One concerns subsonic aircraft, the other, supersonic ones. With the first, consideration has to be given to the influence of cold on the alloys of which the structure is made. With supersonic

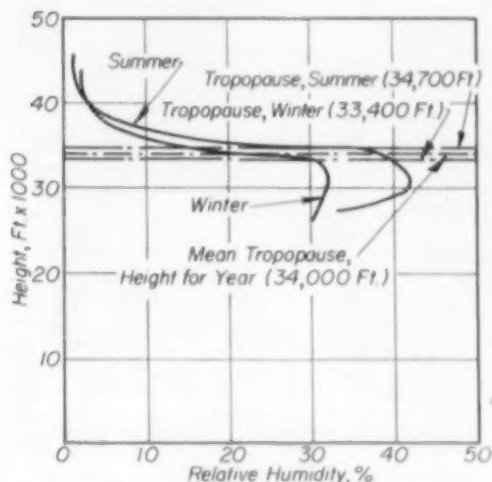
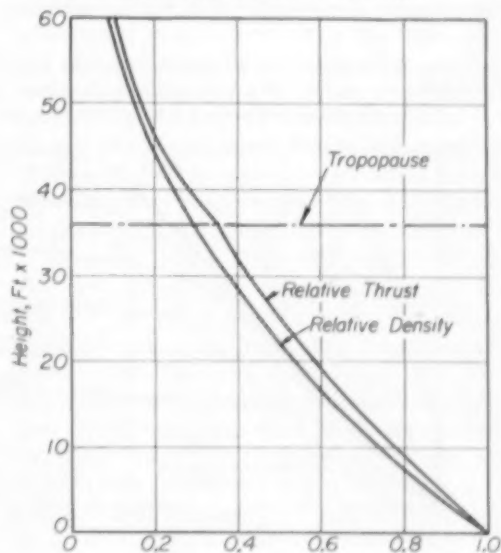


Fig. 4 - The Variation of Relative Humidity With Height. Tropopause heights are those for southern England and are mean values taken from records obtained during aircraft ascents. Winter in this chart refers to the period Nov. 16 to May 15, summer is May 16 to Nov. 15

machines, due to friction of the air, the reverse is the case - high surface temperatures, not low, are the cause of anxiety.

After something like a generation of experiment (a polite word for the more erudite variety of trial and error) there appears to be near uniformity of British opinion as to the best materials for subsonic civil and military air-

Fig. 5 - Variation of Relative Density and Engine (Jet) Thrust With Height



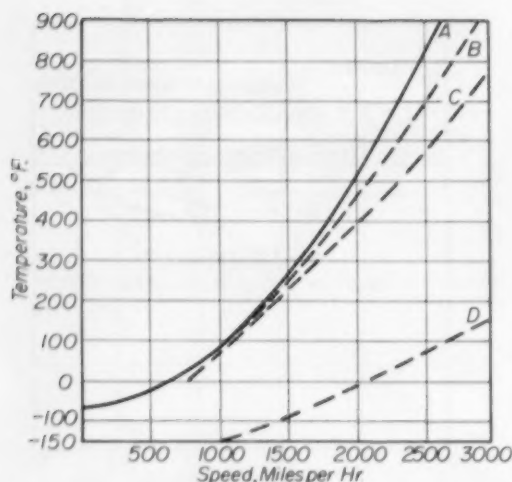
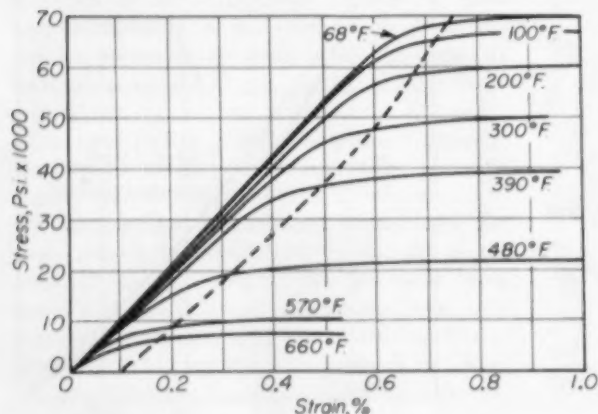


Fig. 6—Relationship Between Speed and Surface Temperature of Aircraft. Curve A is turbulent flow-temperature at 50,000 ft. without allowance for radiation or absorption of solar energy; curve B is for same conditions but with allowance for radiation and absorption of solar energy; C is turbulent flow temperature at 75,000 ft. with allowance for radiation and absorption of solar energy; D is laminar flow temperature at 75,000 ft. with allowance for radiation and absorption of solar energy

frames. The following proportions are thought to be reasonably representative of current practice: aluminum alloys 80%, magnesium alloys 2%, ferrous alloys 12%, copper 1%, miscellaneous materials 5%.

The physical-metallurgical problem of subsonic aircraft largely consists in determining what adverse influence the lowest stratospheric temperature (say -130°F.) has on airframe

Fig. 7—Influence of Temperature on the 0.1% Proof Stress of D.T.D. 364 A (similar to aluminum alloy 2024). All specimens soaked 1 hr. at test temperature



materials. Research on the grand scale, largely carried out in the United States, has established beyond a peradventure that low temperatures generally improve and never adversely influence the static, dynamic and fatigue properties (even notch fatigue) of all current wrought and cast aluminum alloys. Magnesium alloys, while increasing in static strength, show decreased impact resistance, though not to an extent which precludes their use at stratospheric temperatures.

Plain carbon steels, particularly rimming ones or those deoxidized in part or wholly with silicon, show quite dramatic drops in ductility and impact resistance with decrease in temperature. To a lesser degree this is true of the ferritic chromium alloys. On the other hand, austenitic steels containing chromium and nickel within certain prescribed proportions are improved in every way by cold. Between the unalloyed and the highly alloyed steels, there is a wide range of nickel-chromium-molybdenum ferritic steels, which, while decreasing in ductility and impact resistance with fall in temperature, are entirely suitable for use in subsonic stratospheric aircraft, provided always they have been given the correct heat treatment. High-tin solders (used for making electrical connections) undergo most pronounced embrittlement. Should the tin content be reduced to below 10%, this difficulty is avoided, but at a very considerable cost in ease of manipulation. (To describe such solders as "hard to use" would be regarded by a practical tinsmith as the understatement of a lifetime.) Finally, a word as to titanium, that Cinderella of aircraft metals: Its impact resistance is markedly reduced by expected low temperature, but experience with the metal and its alloys is as yet too limited to permit making any pronouncement of the extent its utility is impaired.

The foregoing shows how, with but minor changes in the selection of alloys, metallurgical difficulties which could arise in connection with subsonic aircraft can be anticipated and overcome. It is now necessary to consider the supersonic machine. Figure 6 discloses the surface temperatures which will have to be met at two heights, 50,000 and 75,000 ft., at airspeeds up to 3000 miles an hour, under two conditions of airflow, turbulent or laminar. The former is characteristic of all existing aircraft. The latter is a state of blessedness for which all aerodynamicists hope. However, its attainment, like

entry into Heaven, is open to doubt. Certainly if religious pictures are to be believed, laminar flow was unknown to the angels at the time they had their portraits painted.

Dealing with the world as it is and not looking too far forward, a speed at stratospheric heights of 1400 miles an hour appears to be attainable within the next ten years. From Fig. 6 this indicates that the surface equilibrium temperature of a machine flying at 50,000 ft. will be about 100° C. (212° F.). Figure 7 gives, at different temperatures, the stress-strain diagrams of the wrought aluminum alloy extensively used in British airframes (it is akin to 24 S or 2024). This material, or more heat resisting variants of it, will prove adequate under the conditions cited. If higher speeds are required and (doubtless they will be by the military who, like Oliver Twist, ever ask for more), then other structural materials will be necessary. The problem is not surely an immediate one, though it is appropriate to speculate on its solution. Titanium may well be the answer. Figure 8 gives stress-strain diagrams at varying temperatures of one of the newest titanium alloys, Ti-155 AX. It, or more likely a more heat resisting alloy yet to be produced, may prove adequate for the structure of stratospheric airplanes flying up to about 2500 miles per hour. If speeds beyond this are called for, then, at present, there appears to be no answer but steel. Thus in part is justified Rudyard Kipling's dictum, "Iron, cold iron, is master of them all."

As a tailpiece to an article which is both a record of what is and a prophecy of what may be, a singular fact should be mentioned. It justifies the opening sentence: "Problems are the inevitable consequence of change in conditions."

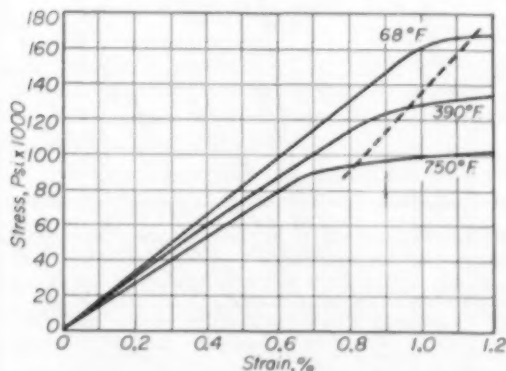


Fig. 8 — Influence of Temperature on the 0.1% Proof Stress of Titanium Alloy Ti-155 AX

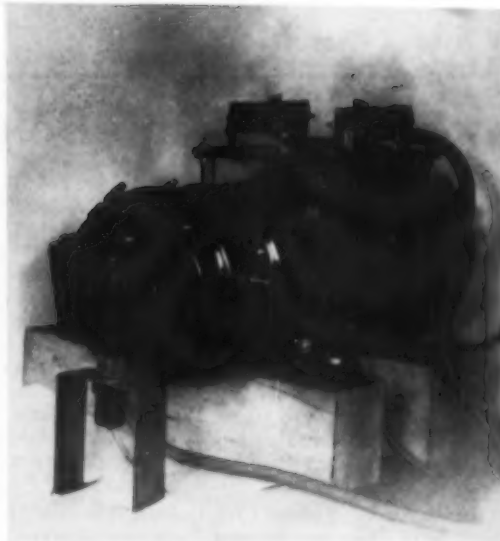


Fig. 9 — The Dark Area Above the Rotary Converter Is Carbon From Commutator Brushes Which Disintegrate When Machine Is Run Under Stratospheric Conditions

When subsonic aircraft first entered the stratosphere, a strange, frightening and wholly unexpected thing occurred. The carbon brushes of dynamos and motors carried in such aircraft, which, at lower heights had always proved themselves adequate, suddenly began to wear at a quite prodigious rate, from half an inch to an inch per hour! Figure 9 shows an aircraft rotary converter running in stratospheric air. This machine would have operated satisfactorily for years at low levels. The black cloud is not a shadow. It is carbon dust arising from the disintegrating brushes.

To the nonaeronautical reader, this may appear to be merely an interesting but unexpected consequence of invading pastures new. To the aeronautical reader, however, it provokes feelings akin to horror, for in the modern airplane man has created a monster which he, unaided, can no longer control. He must have the help of electric power generated within the machine, which converted therein into mechanical energy, will enable him to do what he is now by himself too puny to do. Electricity is a genie and man is its slave. The course of the catastrophic wear of standard carbon brushes is undoubtedly the dramatic change shown in Fig. 4 in the relative humidity of the atmosphere, once the tropopause is penetrated. Research again, largely and most ably conducted in the United States, has shown how, by different methods of brush manufacture, a difficulty (initially of the first magnitude) can be reduced to endurable proportions.

Experiment teaches, but it is imagination and courage which have conquered a new world. ☼

H-Bomb Defense: Absence*

For Nagasaki-size atomic bombs [equivalent to 20,000 tons of TNT] the radius of severe damage is about 1 mile; suburban sections of large target cities had only to worry about a wild miss.

Thermonuclear weapons [at least 100 times as powerful] change all this. Only a single bomb would be necessary to destroy a city, and bombing errors of a mile or more do not change the expected damage to suburban areas or affect a plan of action or evacuation. In this event the problems of "civil defense" derive primarily from two considerations: (a) How big is the bomb and (b) how will its blast and heat effects vary in the twilight zone between total destruction and no significant damage?[†]

Bomb Size — Federal Civil Defense Administration's 1955 plans assume that "any city attacked, with very few exceptions, would be substantially destroyed". This means that Philadelphia, with an area of 127 sq. miles, equivalent to a circle of 6.4 miles radius, would require one bomb of 1,600,000 tons TNT equivalent (1.6 megatons). Since one of our bombs tested at Bikini in 1954 had 5 to 7 megatons equivalent, the writer estimates appropriate bomb sizes for defense planning to be as follows: 1956: 6 megatons. 1957: 12 megatons. 1958: 24 megatons.

Blast and Heat Damage — The graph, scaled up from the official "Effects of Atomic Weapons",

*Excerpts from an article by Harold A. Knapp, Jr. entitled "South Woodley Looks at the H-Bomb", in *Bulletin of the Atomic Scientists* for October 1954, p. 306. Matter in brackets [] represents interpolations by the editor of *Metal Progress*. Dr. Knapp is a member of the Navy Department's staff and civil defense director of South Woodley, Va., a town of 250 homes and 1000 people, 10 miles west of the White House.

[†]Dr. Knapp says nothing about damage from gamma radiation, or from radioactive dust—"fall-out". A.E.C. Commissioner Willard F. Libbey said at a Conference of Mayors on Dec. 2, 1954 that bombing would probably be planned for air bursts because "a bomb fired close to the surface has restricted area of blast and thermal damage". An air burst "is relatively harmless, radiologically speaking, as far as local contamination is concerned", he continued.

summarizes the effect of bomb size on peak blast overpressure and radiated thermal energy on a very clear day. [Markings on the curve are taken from tabulations in Dr. Knapp's article, and indicate that *total* destruction from blast and heat may be expected for distances up to six miles for a 6-megaton air burst on a clear day, and nine miles for a 24-megaton bomb.] As to *minimum* safety levels, 3 psi. and 3 cal. per sq.cm. constitute the writer's best guess. [This means an approximate distance for unshielded persons of 13 miles from a 6-megaton bomb and 16 miles from a 24-ton bomb.]

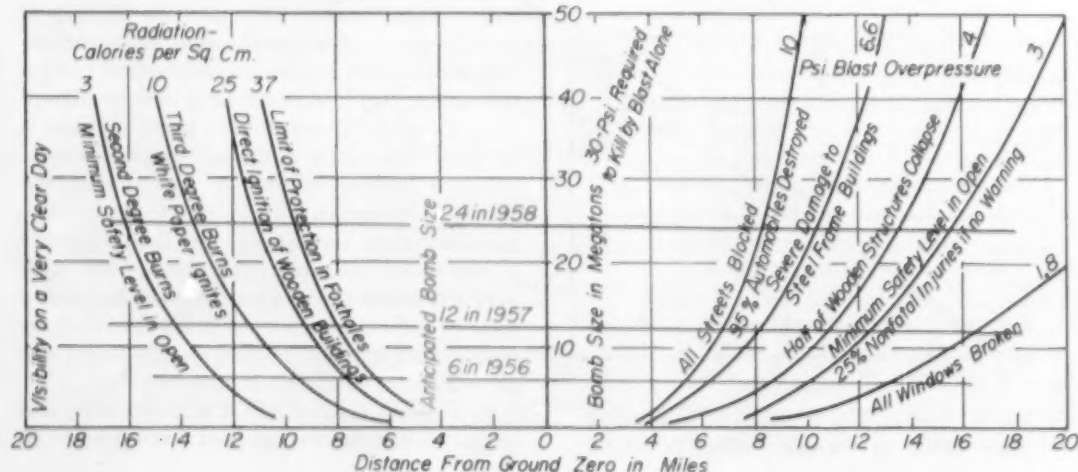
FCDA planning for 1955 assumes one hour advance notice, which should enable most people to move an average of two miles. Even without warning, a blinding flash in the sky would give a person eight miles away about 5 sec. before the heat wave reaches him, which is enough to get behind an opaque object, and 40 sec. before the blast wave arrives. With practice it takes only 2 min. to close doors, windows and blinds in a house, and an alert and trained community can take shelter in 3 min.

As to evacuation, assume conditions in 1958 when residents of South Woodley, 10 miles from the center of Washington, would have to move 6 miles to reach minimum safety. If the roads were clear, 10 min. would be adequate in an automobile, 30 min. for most boys on bicycles. On foot, pushing a baby carriage, would take 2 hr.

It does *not* seem reasonable to assume that things could be kept moving without a great deal of planning, practice, and public education. The civil defense measures which seem to offer the greatest chance for saving lives and property are:

1. A warning system which allows a rapid determination of whether or not there will be time to evacuate.
2. A pre-bombing evacuation plan.
3. Special outdoor shelter.
4. First aid training and equipment.
5. Plans and equipment for extinguishing fires before they have an opportunity to grow or spread.

Estimated Amount of Heat Radiation (Left) and Blast Pressure (Right) at Various Distances From Ground Zero as Affected by Bomb Size



The Pitted-Tank Mystery

By MARJORIE R. HYSLOP*

If a stainless retort in an ammonia dissociator
was rapidly penetrated by pits in the upper head, starting from the outside,
some near a weld, others in smooth plate,
where would you look for the cause?

THIS is the story of the failure of three tanks—a failure so mystifying that the services of a whole corps of metallurgical sleuths were required to break the case.

The victims were a set of three stainless steel ammonia dissociator tanks—or perhaps we should say the victim was the Universal Spacecraft Products Corp., which bought the tanks from the Contraption Mfg. Co., which got the heads and shells from A. Middleman, Inc., steel supplier, which purchased the steel from two companies—the Neverstain Steel Co. and the Everbright Steel Co.

When the first tank failed after only eight months of service (it was expected to last many years), it was only natural that the Universal Spacecraft people should think they got stuck with some pretty poor merchandise. They turned first, of course, to the trouble shooters at Contraption Mfg. Co., who pointed out, somewhat aggrieved, that they had sold more than 200 similar units over a period of years with no complaints. Perhaps the Middleman outfit got

*Managing Editor, *Metal Progress*. The material for this "Whodunit" was provided by the research laboratories of Armco Steel Corp.



Fig. 1 - Ammonia Dissociator Tank of Type 309 Stainless Steel Which Failed by Localized Pitting Adjacent to Circumferential Weld Seams. Note nodules of scale atop tank which were removed from pits in head and shell

hold of some poor steel. Middleman countered with the suggestion that the vessels might not have been properly cleaned after fabrication or that the white lead paint used by the Contraption Co. to mark the shells and heads during fabrication might have had something to do with it. Contraption didn't hold with this idea because they had never before thoroughly cleaned or pickled their tanks prior to putting them into use, and they had been using the same marking paint for years without trouble. The upshot was a joint investigation conducted largely by the two steel manufacturers with minor assists from the other three companies involved.

Metallurgical detective work, like any other, requires first an examination of the corpse, sometimes an autopsy, always a photograph. The corpse is shown in Fig. 1—a tank 26 in. in diameter, made from Type 309 stainless steel

(13.5% Ni, 22.5% Cr, 0.20% C), with shells $\frac{1}{2}$ in. thick and dished heads $\frac{1}{4}$ in. thick, arc welded with Type 310 covered electrodes. For ammonia dissociation, the tank is filled with nickel shot (a catalyst), and completely enclosed in an electric resistance furnace which heated it to about 1750° F. As shown in Fig. 1, the failed tank had a ring of large pits, the size of half a golf ball, around the straight flange of the top head. There were similar pits around the shell plate within 2 or 3 in. of the weld between the shell and head. Two or three of these pits had eaten completely through the shell. There were no pits adjacent to the longitudinal seam. All of the pits were on the outside surface.

The other two tanks operating at Spacecraft Products Corp. had been in service for six months, and *their* outside surfaces were also heavily corroded or scaled in localized areas.

So much for the corpse. The autopsy was begun in the laboratory of the Everbright Steel Co. and consisted of chemical analysis, spectrographic analysis, metallographic examination, hardness and bend tests. Chemical analysis showed that both weld seam and shell plate were of conventional composition for Type 309. No explanation for the preferential attack of the shell plate. Metallographic examination indicated that the scaling was a form of accelerated high-temperature oxidation — something that could be caused by localized contamination, perhaps an oxide of molybdenum, vanadium or lead. The inside surface of the tank was heavily nitrified by the dissociated ammonia, but this seemed to have no relationship to outside trouble. At this point another expert was called in — a consultant who made extensive X-ray diffraction analyses. His report supported the idea of accelerated oxidation but failed to identify the contaminant.

Despite the fact that the *quality* of the steel was now pretty well ruled out as a suspect, the second steel manufacturer got busy on the case — he had two similar ammonia dissociators for making prepared atmospheres in one of his own plants and hoped to get more than eight months' use out of them!

All the evidence so far collected was therefore transferred to the research laboratory of the Neverstain Steel Co. and the case assigned to Joe Thursday, research welding metallurgist. In search of the contaminant, Thursday decided to supplement his routine chemical analysis (which checked previous results) with spectrographic analysis. This ruled out the previous supposition that arsenic, molybdenum, lead or vanadium had done the dirty work.

Macro-etch specimens provided another bit of evidence when Thursday examined his specimens a little more closely and found that a shallower case similar to the nitrified case on the inside also existed on the *outside* surface just below the pits. This he couldn't explain.

Scratching his head, he decided to run some oxidation tests. A pitted section from the dissociator tank, together with a smooth reference sample of regular Type 309 steel, was heated to 1950° F. for 125 hr. On cooling, the control specimen was covered with a normal, moderately heavy scale. The tank section scaled in the same way, but the pits were covered with a much heavier layer, which suggested that the contaminant might still be present. Since the inside surface of the tank scaled in a normal manner, the

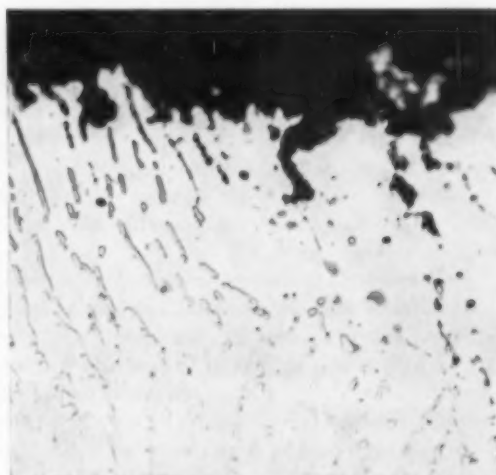


Fig. 2 — Structure of Specimen of the Failed Tank Taken From a Point Below One of the Corrosion Pits Is Largely Nitride Compound in a Matrix of Austenite. Oxides at surface extending inward. Dark particles are sulphide inclusions. Unetched, 500X

nitrified case below the pitted areas could not be responsible for the heavy scaling. Our detective suspected then that the case formed as a result of metal loss, or that the penetration of some element had lowered the solubility of the austenitic metal for nitrogen.

Accordingly, he exposed another small section to lead oxide at 1600° F. for 1½ hr. and looked at it under the microscope. This showed that as the steel was dissolved or oxidized away, a layer of the nitride-like compound formed beneath the surface. Apparently, the wall of the tank — even at the outside surface — was saturated with nitrogen. As the pits grew, the nitrogen was not lost with the metal, but accumulated to form the nitride compound. While this could explain the presence of a nitrified case beneath the pits, it still did not shed any light upon the actual cause of the pitting attack.

As part of his collection of evidence, Joe Thursday ordered a thorough metallographic survey of the outside and inside surfaces of the tank and of the pitted sections. There must, he thought, be a clue in the micrographs. So he spread them out before him and examined them one by one. Suddenly he spotted what he was looking for. The micrograph of the area below a scaled pit (Fig. 2) showed not only the nitride compound (gray) in a matrix of white austenite, but also some dark particles that did not appear in the other sections. Selective etching revealed them to be sulphide inclusions. Chemical analy-

sis confirmed sulphur penetration — the normal scaled surface contained 0.019% sulphur but the surface within a pit contained 0.036% sulphur. This explained the inefficacy of the earlier spectrographic analyses because sulphur is not ordinarily detected with this instrument.

Thursday now knew he was hot on the trail. At least he had found the probable instrument of destruction!

Still another experiment was needed to prove that sulphur was the contaminant. Some small coupons from the unpitted tank wall were prepared with a hole drilled in the outside surface. A small mound of powdered refractory brick was heaped over the hole. In some of the specimens the refractory powder was mixed with 20% elemental sulphur, while some were mixed with 20% iron sulphide. At this point, Thursday demonstrated his sleuthing skill by covering some of his samples with a crucible so as to reproduce the stagnant atmosphere which surrounded the tanks when cased in a closed electric furnace. A control sample, drilled, but without the brick dust, was included in the group.

Thursday's samples were heated at 1750° F. for 100 hr. The only specimens showing any attack were the two which were exposed to elemental sulphur and iron sulphide *and covered by a crucible!* Such a sample is shown in Fig. 3; it closely resembles Fig. 2 of the actual failure — the same nitrided case, the small sulphur particles that penetrated (mostly intergranularly) into the steel, and the accelerated oxidation that followed the penetration of sulphur.

Finding of the instrument of destruction carried the case to within one step of complete solution. It remained only to identify the culprit in the form of some sulphur-bearing material on the tanks which failed so quickly. The scene therefore shifted to the Universal Spacecraft Products Corp. where Joe Thursday assembled representatives of that organization, of the Contraption Mfg. Co., A. Middleman, Inc., and the Neverstain Steel Co. The Universal Spacecraft man pointed out that although the steel in the tanks was not responsible for the failures, the sulphurous contaminant may have reached the tanks while in the hands of the fabricator, while en route by rail, or while being installed at the plant. The matter of payment for the tanks would be a difficult question to settle unless the damaging material and its source were identified.

As noted earlier in this history, neither marking paint, cleaning sequence, particles of welding slag, nor any other fabricating operation in the

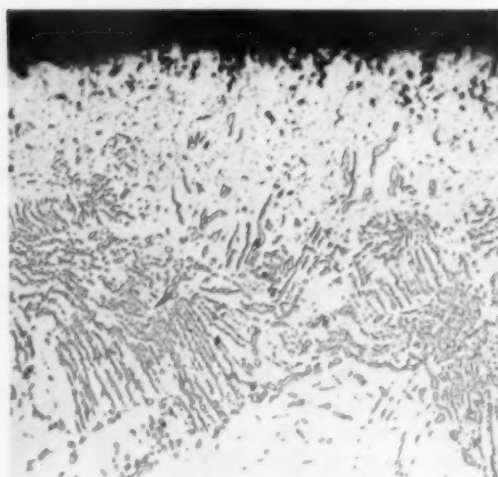


Fig. 3 — Surface of Unpitted Tank Specimen Which Was Exposed to Mixture of Powdered Refractory and 20% Sulphur Under Crucible for 100 Hr. at 1750° F. Note formation of nitride compound just below surface, penetration of sulphur, and ensuing oxidation from surface. Unetched, 250X

Contraption plant seemed to locate the guilty sulphur. It was even less likely that it could have been acquired during shipment.

At this point the investigating group visited Spacecraft's gas generator building to inspect the ammonia dissociators, several of which were in operation, while some had been equipped with new tanks but not yet fired up. Samples of four possible contaminants were removed from these tanks and taken back to the laboratory.

The first two samples were of insulating brick and asbestos brick, found scattered over the head of inoperative tanks where particles had fallen during installation or removal of the cover. The third sample was from one of the operating tanks and consisted of a heavy, yellow incrustated deposit on the weld joint where the top of the tank was joined to a discharge pipe. The fourth sample was of powdered hand soap which had been applied in a thick solution to the pipe joints while the system was pressure-tested.

Back in his laboratory, Joe Thursday analyzed the four materials for sulphur and found:

MATERIAL	SULPHUR
Insulating brick	0.010%
Asbestos brick	0.43
Soap powder	0.10
Deposit from welded pipe joint	1.02

The amount of sulphur in the asbestos brick seemed high enough to warrant investigation. While the soap—a synthetic detergent of the sul-

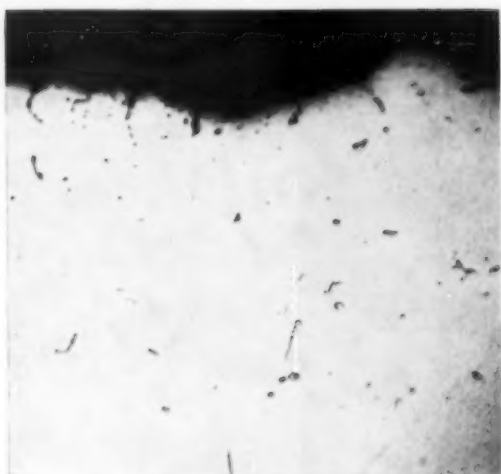


Fig. 4—Type 309 Laboratory Specimen Exposed to Powdered Asbestos Brick at 1750° F. for 115 Hr. Showing Normal Oxidation Attack. Unetched, 500×

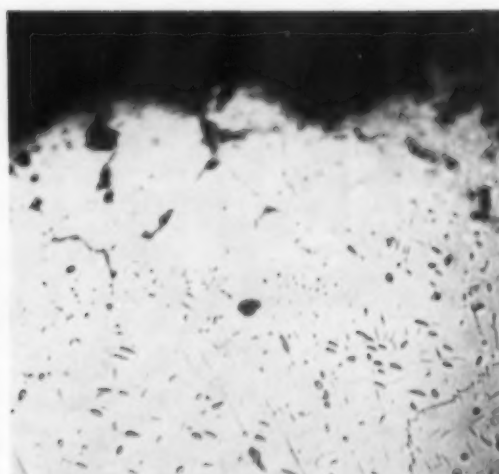


Fig. 5—Type 309 Laboratory Specimen Exposed to Powdered Soap at 1750° F. For 115 Hr. Showing Penetration of Sulphide Particles, Intergranular Oxidation, and Nitride Compound. Unetched, 500×

phonate type—contained only a little, the very high sulphur in the deposit removed from the pipe weld suggested it might have been concentrated when the powder was heated.

Thursday again ordered laboratory contamination tests—small mounds of the powdered insulating brick, asbestos, and soap were placed on coupons from the uncorroded portions of the tank, covered with a crucible, and exposed at 1750° F. for 115 hr.

After cooling, the insulating brick and asbestos were unchanged, but the specimen bearing the soap powder had produced a substantial quantity of black flaky scale and a small amount of yellow incrustation similar to the deposit found on the pipe joint. Sulphur analyses were:

RESIDUE	SULPHUR
Insulating brick	0.010%
Asbestos brick	0.45
Soap powder and black scale	0.048

This suggested to Detective Thursday that the sulphur in the insulating brick and asbestos is stable, while that in the soap may concentrate during early stages of heating and then diminish by diffusion into the steel or by volatilization.

Joe made more micrographs. Just as he expected, the specimens exposed to insulating brick and asbestos (Fig. 4) showed no unusual attack or structure. On the other hand, the coupon exposed to the powdered soap (Fig. 5) developed the selfsame condition as the failed tanks—namely, penetration of sulphide particles

into the steel, intergranular oxidation, and a substantial quantity of nitride compound just below the surface.

The evidence pointed incontrovertibly to the culprit. Soap was the material that contaminated the outside surface of the tanks, produced the sulphur penetration, and dug the pits!

Only one flaw remained in the argument. The workmen had been instructed to pressure-test only the field-welded joint at the discharge pipe, yet the corrosion pits followed the circumferential seam where the fabricating company, far, far away, had welded the head of the tank to the shell. Here Thursday applied his powers of deduction. Would it not be possible, he said, that the workmen had been overzealous and plastered soap solution over all welded seams in reach? Indeed the pattern of attack on the tanks did appear to be related to the brushing of soap solution over welded areas, occasional dripping of the solution from container or brush, and possibly some running or spreading of the dried soap as the tank was heated to operating temperature.

Perhaps somebody should have been booked on a 592 (failure to remove grease, oil, or other foreign materials from the surface of stainless steel prior to being placed in service), but the unusual circumstances seemed to warrant closing the case *nolle prosequi*. The Universal Spacecraft Corp. charged off the loss to experience, and Joe Thursday went back to his laboratory to tackle the next project.

Fine-Grained Brass for Deep Drawing

By CHARLES A. TURNER* and STEPHEN P. BANNO†

A continuous annealing method for deep drawing brass (85-15 and 70-30) produces a material having fine grain, which eliminates "orange-peel", while retaining the ductility of a coarse-grained structure.

IT IS AXIOMATIC among users of brass strip for press drawing that deep drawn articles require a coarse-grained material (0.020 mm. minimum), this belief being based on their experience. This theory is upheld by the evidence that when the conventional batch practice is used to anneal strip, the increasing grain size decreases the tensile strength and increases ductility (elongation) as indicated in the tensile test. However, a recently installed continuous annealing line (Fig. 1) is producing strip having deep drawing quality and a fine grain. This departure from the accepted practice revises some established concepts of the influence of grain size on mechanical properties.

In this new continuous method employed at the Somers Brass Co., Waterbury, Conn., a single strip of brass, 0.004 to 0.020 in. thick, is fed into the annealing furnace at speeds up to 190 ft. per min. (the fastest in the brass industry today), where it reaches annealing temperature in but a few seconds and is then quickly cooled. The outstanding characteristic of this fast-annealed strip is its superior ductility associated with the uniformly fine grain. Most of the production is strip supplied to the "eyelet" trade for deep drawn articles, such as lipstick containers and fountain pen caps (Fig. 2). This strip must be ductile and easy to buff.

*Metallurgist, Selas Corp. of America

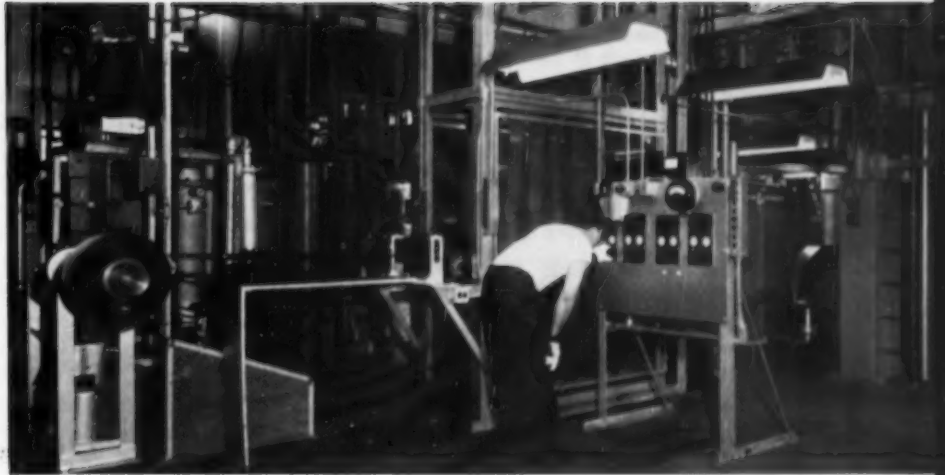
†Metallurgist, Somers Brass Co.

When strip for such applications is processed by batch annealing, the required ductility is obtained at the expense of grain size. The objectionable feature of a coarse grain for any finishing work is the attendant rough "orange-peel" surface which is difficult to polish. The brass as conventionally processed for deep draws is a compromise between coarse grain for ductility and fine grain for improved surface.

Figure 3 compares grain sizes of 85-15 brass strip for deep draw finishing work as processed at the Somers' plant by the continuous and the batch methods. The coarser grain (0.020 mm.) is typical of material from batch annealed coils and the fine grain (0.010 mm. maximum) of the high-speed continuous annealed strip.

By the new continuous annealing method employed at Somers Brass Co., heating is so rapid (less than 10 sec.) that the strip is at a high temperature before nucleation begins. The high heat accelerates the rate of formation of nuclei and provides sufficient energy of activation to effect instantaneous nucleation at all points of stress concentration. Therefore, recrystallization is completed before any growth of the unstrained grains can start. To arrest grain growth by coalescence the strip is cooled rapidly by water quenching. Such rapid heating and cooling results in an extremely fine-grained structure having greater ductility than that produced by any other annealing method.

Fig. 1—Exit End of Sels Continuous Annealing Furnace at Somers Brass Co. The strip, traveling at speeds up to 190 ft. per min., is quickly cooled before being exposed to air



The continuous annealed brass offers another advantage: According to H. L. Walker and W. J. Craig ("Effect of Grain Size on Tensile Strength, Elongation and Endurance Limit of Deep Drawing Brass", A.S.M.E. Technical Publication No. 2478), the endurance limit for 10 million cycles of completely reversed stress is almost doubled when the grain size is reduced from 0.024 to 0.004 mm. average diameter. For applications such as diaphragms, or where vibration is an important factor, it may be expected that the life of brass parts will be increased.

Control of grain size by any annealing method depends upon regulation of the time-temperature cycle. Batch annealing requires heating times running to hours to bring the interiors of the coils to annealing temperature if overheating

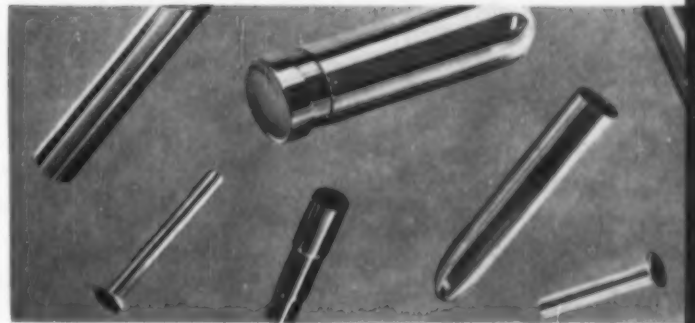
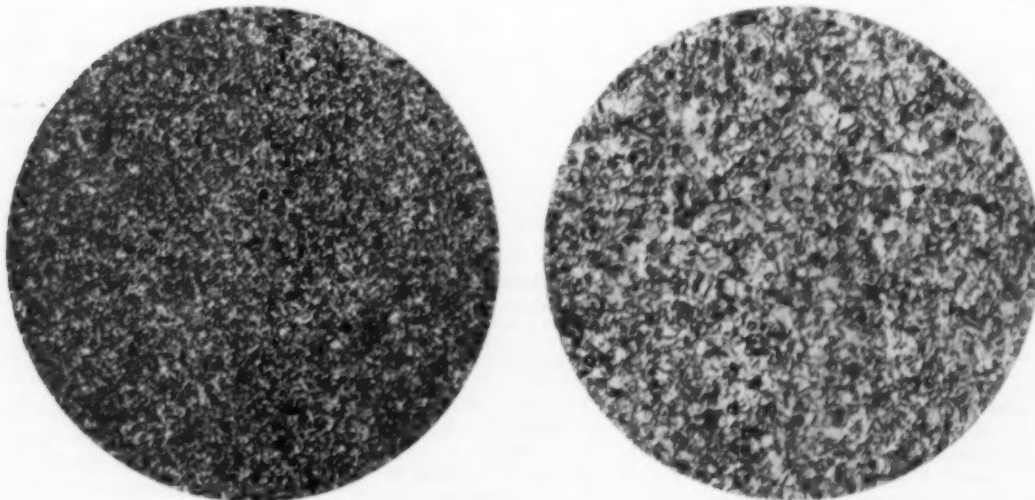


Fig. 2—Deep Drawn Parts Made of Fine-Grained Brass (0.010 Mm.)

Fig. 3—Comparison of Grain Sizes of 85-15 Brass From (Left) High-Speed Continuous Anneal and (Right) Batch Anneal. The former is 0.010 mm. (maximum) and the latter 0.020 mm. 75×



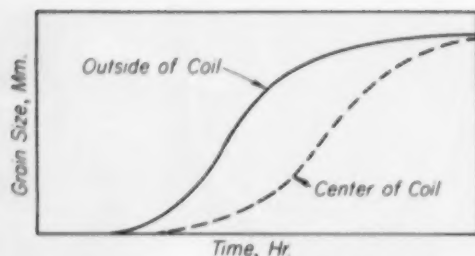


Fig. 4—Change in Grain Size With Time During Batch Annealing of Coiled Brass Strip

of its outer turns is to be avoided; in turn, this means the temperature must be low (approximately 800° F. for production of the finer-grained red brass). The cycles are selected so as to give an equilibrium grain size and thus compensate for the varying times different portions of the coil are actually at peak temperature (see Fig. 4). Though the grain appears to approach an equilibrium size, it is continually growing with increasing time. The result is a variable grain size and a corresponding variation in mechanical properties of the annealed coil.

The continuous method of rapid annealing of a single strand used at Somers is done in a direct-fired gas furnace that consists of two vertical panel sections having refractory walls studded with radiant cup burners. The burners are positioned to give a uniform



Fig. 5—Stress-Strain Relationship in Tensile Test for Brass Strip Annealed by Batch and Continuous Methods. The curves show that the latter has greater capacity for cold work

Table I—Properties of Batch and Continuous Annealed Strip

PROPERTIES	RED BRASS (85-15)		YELLOW BRASS (70-30)	
	BATCH	CONTINUOUS	BATCH	CONTINUOUS
Grain size, mm.	0.020	0.010 (max.)	0.020	0.010 (max.)
Tensile strength, psi.	46,000	47,000	56,000	45,600
Elongation, %	40	49	45	55
Rockwell, 30 T	30 to 40	39 to 41	36 to 45	39 to 40

heat over the full strip width. The strip descends vertically through the furnace and upon leaving it is quickly cooled by a combination steam and hot water quench. During the heating, the strip temperature is continually rising, with no soaking. The time under heat, which depends on strip speed, varies from 3 to 8 sec. When strip speed is increased to meet mill production requirements, higher temperature is used so as to maintain the time-temperature balance that produces the desired grain. The fine grain in red brass is developed at approximately 1300° F., the precise temperature depending on the thickness of the strip and its speed through the furnace. Control of strip temperature is obtained by coordination of strip speed and heat input. A uniform anneal is obtained over the full length of each coil and from coil to coil.

Table I compares physical properties of batch and continuous annealed brass strip that had been processed for the same kind of deep drawn products. The elongation values for the latter show its improved ductility.

The ability of brass strip to absorb work hardening during cold reduction is indicated by the extent of the plastic range in the tensile test. This is illustrated schematically in the stress-strain curves, Fig. 5, that define the plastic range by the spread between the yield point and the ultimate strength.

In conventional batch annealing of high or cartridge brass, varying amounts of impurities, notably iron, make close control of grain size difficult. For this reason an upper limit of 0.05% iron is usually specified for quality brass. It is generally believed that iron has little or no effect upon time or temperature of initial recrystallization but retards grain growth at the usual temperatures for batch annealing. At higher annealing temperatures the iron goes into solid solution and grain growth then proceeds at an accelerated rate. As a result of this rapid growth—and the impossibility of at-

taining a uniform coil temperature in a limited time—the grain structure is coarse and non-uniform.

The literature on the subject states that solid solubility for all iron contents is essentially complete at 1290° F. In continuous annealing by rapid heating, the instantaneous recrystallization takes place at elevated temperatures, where the iron is in solution. With the temperature uniformity and close control of time that this method permits, brass strip of high iron content is annealed uniformly and with a close control of grain size.

Figure 6 illustrates the influence of high iron content (0.115%) on the development of a specified 0.025-mm. grain size in 70-30 brass. Batch annealing (at left in Fig. 6) for this grain size was applied (40 min. at 1000° F.). Complete recrystallization resulted but the over-limit content of iron prevented grain growth. Results were similar after a second treatment at a slightly higher temperature (40 min. at 1020° F.). A coil of this same brass, not previously treated, was then continuous annealed at 100 ft. per min. (approximately 7 sec. to reach 1350° F.), and the uniform and larger (0.025-mm.) grain size was produced (Fig. 6 right).

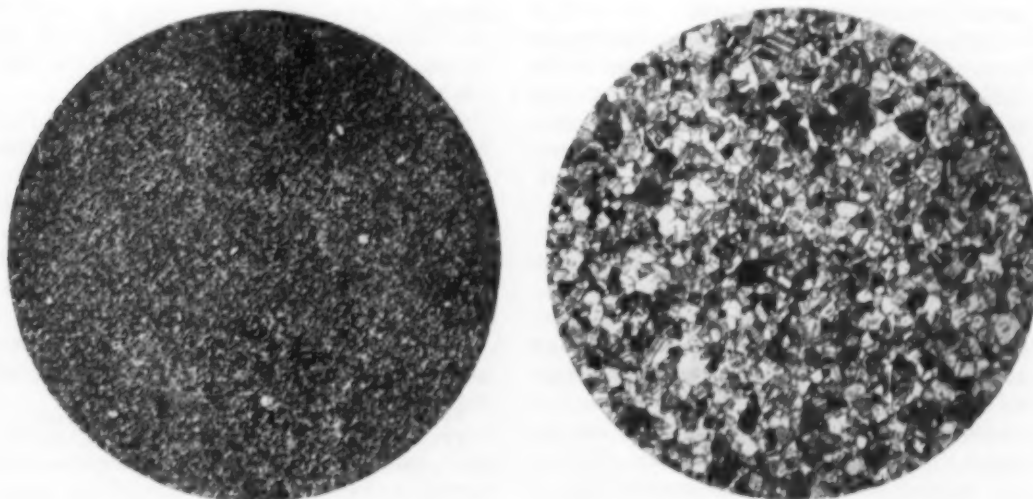
The extremely fine grain, in brass of high iron content, that results from batch annealing does not have the deep drawing characteristics of a continuous annealed fine-grained structure. Rather, the properties of the batch annealed brass are those of a quarter-hard material, which limits its application. The difference in drawability of fine-grained brass of high iron content produced by the two methods appears to lie in

the ability of the continuous method to place the iron in solid solution during heating and to maintain this solubility by the rapid quench to room temperature. In this state the iron has no hardening influence.

To prevent oxidation of strip during batch annealing, coils are heated and cooled in a prepared atmosphere. The long annealing cycle and the loss of zinc at the strip surface by vaporization are inherent problems of this method. "Scalloping", as this loss is called, is confined principally to the exposed edges of the coiled strip where the adjacent laps are not as tight as at the center. The resulting discoloration can be partially removed by pickling, but, for finishing work, complete removal requires costly buffing.


Continuous annealing in this gas-fired furnace requires no externally prepared atmosphere since the gases produced by combustion for heating the strip are nonoxidizing to copper and its alloys. Air and gas for firing the burners are premixed in a combustion controller in a ratio to prevent the occurrence of free oxygen in the products of combustion. The furnace gases consist of nitrogen, water vapor, carbon dioxide, carbon monoxide and hydrogen, none of which oxidize the brass strip. The tightness of the furnace permits operating under a positive pressure to exclude infiltration of air. The strip is under heat for so short a time that dezincification is negligible and a clean annealed product results.

Fig. 6—70-30 Brass With High Iron Content (0.115%). Left: after batch anneal at 1000° F. for 40 min. and re-anneal at 1020° F. for 40 min. Right: after continuous anneal at 100 ft. per min. (approximately 7 sec. to reach 1350° F.) 75×



Anything New in Hardness Measurements?

By S. R. WILLIAMS*

The eminent author of the  book on "Hardness Measurements" comments on the rise in microhardness and portable testers, and reminds us that a fundamental concept of hardness still eludes the theoretical physicist.

BROWSING through Olmsted's "Introduction to Natural Philosophy", I found the following item: "Hardness is that property of a body by which it resists the impression of other bodies that impinge upon it; and the degree of hardness is measured by the quantity of this resistance. If this resistance is so complete as to render it totally incapable of any impression, then a body is said to be perfectly hard."

This was written about 125 years ago. Comparing it with modern definitions, one is led to wonder as to how much progress we have made in our understanding of hardness in a century. Fortunately, we are not limited in our approach to a subject by a definition, but have a much more realistic one which Bridgman has emphasized over and over again: "The attitude of the physicist must be one of pure empiricism." He must pursue knowledge by observation and experiment; his understanding of a physical concept is by certain physical operations which he employs in measuring that concept.

Let me illustrate this point by considering the concept of hardness. What do we mean by the "hardness" of a body? We evidently know what we mean by "hardness" if we can tell in terms of numbers what the hardness of any and every object is. For the physicist or metallurgist nothing more is required.

To find the hardness of an object, we have to perform certain physical operations. The concept of hardness is therefore fixed when the operations by which hardness is measured are fixed; that is, the concept of hardness involves as much as and nothing more than the set of operations by which hardness is determined in terms of numbers. "In general, we mean by any concept nothing more than a set of operations; the concept is synonymous with the corresponding set

of operations." This seems particularly applicable to that property of a body which we call hardness, because we really have no precise conception of hardness.

The past few months seem to have been an open season for advertising hardness testers of all sorts and descriptions. Does this mean (from Bridgman's point of view) that we have as many concepts of hardness as there are kinds of hardness testers? One cannot give a clear "Yes" or "No" answer. O'Neill would seem to have sensed this dilemma in the introductory essay to his splendid book on hardness published in 1933:

"It would not be surprising to learn that work upon a problem which presents so many different aspects had failed to yield anything of real utility. The very reverse, however, is the case. In the realms of hardness, practice has outstripped theory, and the various technical hardness tests have been of the greatest value to industry for judging and controlling the quality of metallic products . . . One of the reassuring aspects of the hardness question is that on the whole the various tests put different metals into the same relative hardness series† or sequence."

One robin doesn't make a spring; neither does eight months of advertising in *Metal Progress* for 1954 decide unequivocally the recent trends in hardness testers, but it is interesting to note that only the static indenter type were advertised during those eight months. Apropos of this point, O'Neill commented on p. 5 of his book: "The production of munitions during the war of 1914-1918 was not without its effect in directing attention more and more toward the Brinell ball

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†The various conversion tables which are commonly supplied for comparing any hardness tester with another is an attest of this point.

method." No doubt the second world war did the same thing, but these world-shaking events did not limit the indenter to the ball form. In fact the recent manufacturers' literature would indicate that the diamond pyramid indenter is running a strong second, at least.

The two world wars with their emphasis on mass production also brought the motor-operated hardness tester to the fore. The new machines are marvels in their automatic controls.

If the recent literature is any yardstick of what is happening in shops, where it is desirable to maintain standards by hardness tests outside of the laboratory, then the *portable* hardness testers must be regarded as a new development, brought to such a degree that their readings may be taken as quite reliable. This again indicates that "the various tests put different metals into the same relative hardness series or sequence", because many of these portable hardness testers

have their scales calibrated to read in Rockwell, Brinell, Vickers, or what-have-you numbers.

It is also to be observed that the microhardness testers are coming in for their share of honors along with the macrohardness machines. It will be interesting to see whether Schulze's observations that "elastic recovery of indentation can be ignored in the macrohardness but not in the microhardness range" will influence the use of one against the other.

The writer still adheres to the old fashioned idea that if we want to get a more fundamental concept of hardness — that is, a quantity measured in terms of length, mass and time — we may still learn something from the *dynamic* methods of hardness testing. This is a point emphasized by the eminent Frenchman, Roudie, in his important book on "Hardness Control in Industry".

In the meantime the present operational procedure is doing a fine job. ❶



Book Review...

Data Books and Handbooks

METAL DATA (Revision of METALS AND ALLOYS DATA BOOK), by Samuel L. Hoyt, Reinhold Publishing Corp., New York City, 526 p., \$10.

ASME HANDBOOK, VOL. 1, METALS PROPERTIES, Edited by Samuel L. Hoyt, McGraw-Hill Book Co., Inc., New York City, 450 p., \$11.

Reviewed by MUIR L. FREY*

THERE is a growing need for good books of this type. The increasing breadth of our metals technology with its proliferation of new materials, special materials whose application must

be carefully chosen for optimum results, and more precise processing confronts all but the experienced engineer with a bewildering number of choices. It is, therefore, essential that the basic data be assembled in convenient form. These books represent the best effort this reviewer has seen to date to fulfill this need but they still, I am sorry to have to report, leave much to be desired.

"Metal Data" is the second edition and is more extensive in coverage than the first and contains much that is good and much that can be readily found nowhere else. For these reasons it will be of value to designers and to many materials engineers. It should be a delight to teachers because it contains much information that can be used to illustrate principles and its broad cov-

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erage will serve as an introduction to many subjects.

The book is also timely. For example, by a suitable selection of data it emphasizes two important trends: first, the effect of temperature on the properties of metals, and second, the increasing use of the notched-bar impact test in evaluating steels. The result of the author's long experience in these areas can be plainly seen. The book is necessarily incomplete in these respects because the fields are developing rapidly and basic data are still accumulating, which is likely to make this material obsolete all too soon.

"Metals Properties" was prepared for the American Society of Mechanical Engineers and is published as the first volume of a proposed four-volume handbook.* It does not cover as wide a variety of materials as "Metal Data". For one who wants or needs no more than a listing of the mechanical and physical properties of a metallic material covered by an A.S.T.M. specification or by an A.I.S.I. or S.A.E. classification, "Metals Properties" is, as a whole, adequate. Except for the mechanical properties, the data presented seem to have been well screened; there is only one value given for whatever property is under consideration. Mechanical properties are in too many instances presented from separate sources. Since the normally expected values are now well known to metallurgists and the variations from the several quoted sources are not large, it is difficult to understand the editor's failure to evaluate his material. Had he done so, the uninitiated reader would have been benefited.

When an author, even one with the broad knowledge and experience that Sam Hoyt possesses, undertakes to compile a book of metal data, he undertakes an assignment which cannot be completely fulfilled. It cannot be all things to all men.

The author's prime problem consists of deciding what to leave out. The decision is doubtless governed by the compiler's experiences, his personal preferences and his ideas of what the reader needs. Since the latter requirement cannot be definitely known, omissions are inherent.

The arrangement of "Metal Data" is logical and, therefore, orderly and usable. "Metals Properties" suffers by comparison in one important respect. It was apparently the plan to arrange the data in numeric sequence of the specifications; however, something interfered in too many instances. Further, such an arrangement of the

*Another volume of the set is reviewed by Mr. Raney on the next page.

A.S.T.M. section mixes cast iron, malleable iron, wrought steel, pipe, valves, sheets, fittings, bars, strip, shapes, plates, nodular iron, cast steel, hot rolled, cold finished, galvanized and what have you in one grand potpourri. This arrangement makes it impossible to readily compare, for example, the properties of hot rolled bars of varying carbon content or of the numerous kinds of pipe made of various materials. Here is a good example of where the loose-leaf system such as *Metal Progress Data Sheets* is superior; the user can then arrange the material to suit his needs, or post or frame individual much-used items.

Perhaps it is a fundamental disadvantage of books of this type that they fail to carry the subject to its logical conclusion and present clearly the known principles of mechanical metallurgy. Not all phases of the subject can be so presented, because this newest branch of the science has yet to change completely from the status of an art to a science, but in those areas where that change has taken place, it is possible to do a fairly good job. In the preface to both books there is a disclaimer to the effect that assembling, sifting and arranging data was all that was contemplated — that is, the author exercised his privilege of limiting the scope of his work. There can be no sensible exception taken to that fact, but there is still room to point out that the job falls short of fulfilling a need of setting forth clearly those valid generalizations about the orderly and therefore predictable effect of chemical composition and mechanical or thermal processing on the physical and mechanical properties of metals. These matters are now of vital importance to more people than any other branch of metal science and technology. Many of the people concerned with materials were not educated as metallurgists and do not readily discern the principle from assembled data. Furthermore, those metallurgists not recently graduated may not have kept fully up-to-date. Yet, without the underlying principles it is next to impossible to handle the voluminous data now available. The mass of data in these books strikingly illuminates this need and yet, in too many important areas, no attempt is made to fill it.

Perhaps a solution would be to use the conventional handbook form, so useful to engineers in all professions for the last 50 years. This would automatically provide for a judicious amount of editorial comment where it is needed and it could also be used, by a suitable selection of section editors, to add specialization where it

counts. An illuminating instance of this is in the section on notched-bar testing in Metal Data.

The section on high-temperature alloys in the same volume is timely and well presented. Here again a warning to the effect that this is a new field developing rapidly would be of value to the prospective user if for no other reason than to advise him that anything but a superficial glance at this field would lead into considerably deeper water than is found in the publication.

Altogether the books represent a worth-while effort in an area most difficult to handle. They are a valuable contribution to the growing literature of metals engineering and we hope that the author will continue to revise and improve them in future editions.

ASME HANDBOOK, VOL. III, METALS
ENGINEERING—DESIGN, Edited by Oscar
J. Horger, McGraw-Hill Book Co.,
Inc., New York City, 405 p., \$10.

*Reviewed by R. R. RANEY**

My first impression of this book was favorable, but I later concluded, after some reflection, that the volume would not attain the objective set out in the foreword by Mr. Sillcox, the chairman of the A.S.M.E. Handbook Board. The commendable aim of the work is contained in the statement, "This Handbook has been prepared to fill the urgent need for a reference manual related to the design engineer's point of view." Mr. Horger's editorial preface, which follows, elaborates on the various problems which confront modern design engineers but the text, written chapter by chapter by 43 authorities, seems to be overly academic. My meaning will be made clear by citing a few examples.

Part Four is entitled "Metallurgical Factors in Design". As a design engineer this title conjures up in my mind a discussion of material analyses with a heavy accent on the effects of heat treatment. Part Four, however, is devoted exclusively to subtle inspection methods based on magnetized particles, X-rays, core-loss measurements, ultrasonics, electric and electromagnetic systems. The material is interesting and the authors display a good deal of erudition, but, as a design engineer who is concerned with the *metallurgical aspects of design*, I would simply have to put

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the book aside and consult some other work.

Or, take the question of "Design Procedures" in Part Six. Design *practice* is covered in a mere nine pages while the next 26 are devoted to design *theory* in the shape of complex mathematical explanations of rather abstract phenomena. The authors of these and other similar articles in the book are undoubtedly authorities — possibly the best in the field — but I have the feeling that they are writing for other authorities and not for people like myself; for I am expected to get a job done without taking time out to get a specialist's education. If I encounter a problem which requires this kind of talent, I hunt up someone who already possesses some facility with these techniques, but I do not consult a "handbook".

The inverse situation is found in the cavalier treatment given such a straightforward topic as "Processing Considerations in Design", Part Five of the text. Design engineers of my acquaintance are vitally concerned with creating designs which can be fabricated with the facilities available, yet over half of this short 20-page section is devoted to a learned discussion of surface finish. Useful? Yes, but not to the practical exclusion of a host of other problems concerned with efficient processing. Even so significant a process as welding gets less than two pages' notice.

I suppose that all "assembled" volumes suffer from a certain amount of discontinuity in style or emphasis. I know that if I were one of the contributing authors, I would certainly resist any attempts by the editor to fit me into some stereotyped pattern. On the other hand, the handbooks which are in greatest demand by my engineering associates are those in which the editor has played the leading part. By some means, the subject matter has been tailored to the point where the sections are balanced and where each article gives the feeling of being aware of every other article. The advantage is precisely this — that the user has equal confidence in every page of the book and has no doubt about what is to be found when he consults the volume afresh. Anything short of this constitutes merely an anthology whose use may provoke as many disappointments as satisfactions gained.

Mr. Horger's preface closes with the statement that this "handbook is intended for use by practicing design and research engineers but will be found usable by advanced students". I would revise this to say that the handbook is intended for advanced students but will be found usable by practicing design and research engineers. ☛

Choosing a Titanium Alloy

By LEONARD D. JAFFE*

The many alloying metals proposed for titanium have a consistent action except vanadium and aluminum. All of them have virtues. Some of the so-called interstitial elements (C, N, O, B, H) are powerful strengtheners but are equally damaging to toughness and workability. Effects of composition and heat treatment are interrelated and systematized.

IN THE ARTICLE ON "Heat Treatment of Titanium Alloys" in *Metal Progress* last month (p. 101) an attempt was made to draw together the results of many researches and publications into a somewhat systematic and coherent pattern. The view was taken that the properties of the commercial alloys depend upon the properties and arrangement of their microconstituents, and heat treatment is important in bringing out optimum microstructure. The present article will similarly make a systematic review of the effects of composition on titanium alloys.

In Fig. 3 of the previous article a curve was drawn showing the effect of cooling rate from the all-beta region on microstructure, hardness and brittleness. This diagram is now repeated as Fig. 1 with notations in color showing the effect of alloying.

Unalloyed titanium, as noted at upper right, will have a microstructure almost entirely alpha, whether quenched (condition as shown on the curve under the x symbol) or air cooled (curve point directly under the circle symbol). Alloy content generally shifts conditions toward the left along the curve; for example, increasing

manganese content shifts the quenched and air cooled structures consistently to the left, a 12% Mn alloy producing soft beta when quenched and a moderately hard mixture of beta and omega when air cooled.

However, various alloying elements have different potency. Thus, the notations on the diagram show that a little vanadium and aluminum have little if any effect on room-temperature microstructure; also that 5 Fe and 4 Mn, 4 Al have similar results — hard and brittle omega and beta if water quenched, fairly soft alpha and beta if air cooled.

The positions of the alloy notations in color in Fig. 1 will be shifted to the right by isothermal transformation of beta and also by tempering after cooling from the beta condition. When estimating the changes in properties with time of tempering or aging, as schematized by Fig. 1, the starting point would be the hardness *prior* to tempering. For isothermal transformation, the starting point, essentially, would be the as-quenched position.

Oxygen and carbon contamination will also shift the expected microstructure to the right of that indicated on the curve of Fig. 1.

Thus, the various alloying elements (excluding aluminum and the interstitials C, N, O, B,

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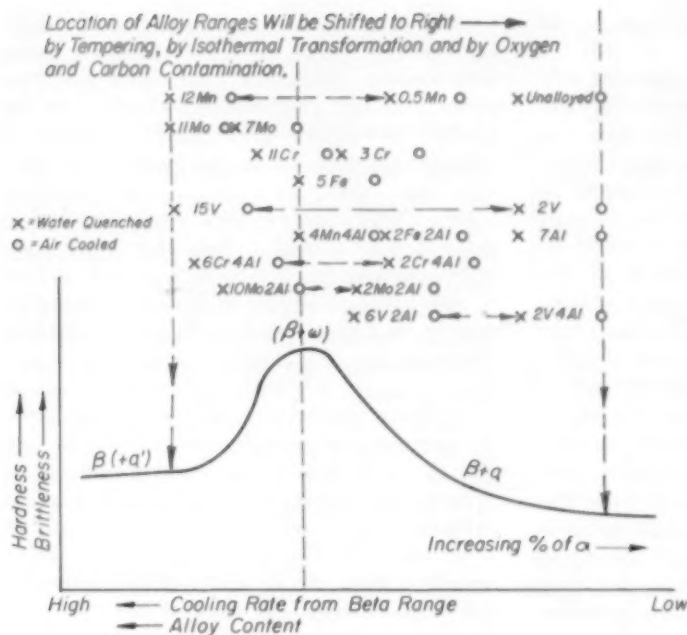


Fig. 1 - Generalized Curve Showing Effect of Alloys as Noted in Color on Structure of Titanium Alloys

H) are generally similar. They dissolve preferentially in beta and stabilize it at the expense of alpha; that is to say, lower the temperature range of beta stability and the range of martensite formation. They strengthen the alloy, with a corresponding decrease in ductility and toughness. They retard the rate of transformation of beta into beta plus omega into beta plus alpha, moving the material to the left on Fig. 1; that is, they increase hardenability. Alloying elements also increase the density of titanium-base alloys, since they have greater atomic weights.

Although rather small amounts of iron and silicon as impurities have been reported to lower the toughness and ductility, iron in larger quantities acts much the same as other alloying elements. There is reason to suspect that at least some of the observed differences in properties of various titanium alloys are actually due to interstitial impurities accidentally introduced with the intentional additions.

The alpha and the beta transus lines and the M_s temperature may not be lowered the same

amount for percentages of different alloying elements having the same effect upon rates of reaction (hardenability). Thus, 10% of molybdenum increases the hardenability at least as much as 10% of chromium, but its effect is less on the start of martensite formation. This may lead to some differences in properties in the two alloys similarly heat treated. It has not been established whether combinations of various beta-stabilizing elements have different behavior from that of a single alloying element. Some alloying elements, such as iron and chromium, may tend to precipitate as intermetallic compounds with titanium during long-time service at elevated temperatures. Therefore, manganese, molybdenum, or vanadium, which precipitate as intermetallic compounds slowly or not at all, may be preferred.

Vanadium is exceptional in being the only element known which reduces the height-base ratio (c/a ratio) of the hexagonal crystallographic cell. Since ductility and toughness in titanium lattices appear to be associated with low c/a ratios, it is possible that vanadium will offset

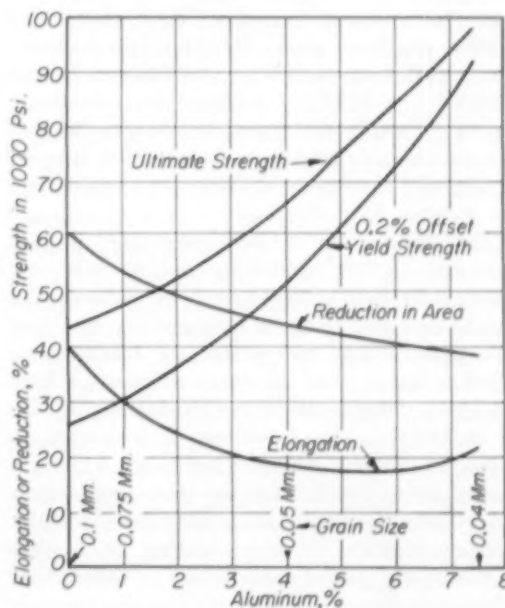


Fig. 2 - Effect of Aluminum on Tensile Properties of Annealed Titanium (Ref. 1.) High-purity 0.040-in. strip was rolled at 1560° F. (850° C.), held 3.5 hr. in vacuum at rolling temperature and furnace cooled

the embrittling effects of other elements on the alpha phase.

Aluminum is the only element dissolving substitutionally in titanium which is known to stabilize alpha rather than beta. There has been considerable interest in titanium-aluminum alloys for this reason. Aluminum strengthens alpha, as shown in Fig. 2, but above 6 or 7% the material becomes rather brittle and cannot be rolled by present techniques—possibly because of the increase in c/a ratio. Aluminum seems to have little effect on the response of titanium alloys to heat treatment. It also lowers their density.

Oxygen and nitrogen, which dissolve interstitially in titanium, are strong alpha stabilizers. As shown in Fig. 3, they produce large increases in strength and large decreases in ductility and toughness, nitrogen having just about twice the effect of oxygen. Decreases in ductility and toughness are greater than those produced by substitutional alloying elements giving the same strength, so nitrogen and oxygen are generally undesirable in titanium. Oxygen markedly accelerates decomposition of beta and decreases hardenability. Nitrogen probably acts likewise.

Boron appears to be only very slightly soluble in titanium; its effects on heat treatment and properties remain to be investigated.

Carbon—The titanium-carbon phase diagram is shown in Fig. 4. Carbon is generally undesirable, as it lowers ductility, toughness, and ease of fabrication, particularly weldability and machinability. Dissolved carbon raises strength more than when combined as $TiC(\delta)$, but it also lowers toughness more. Thus, holding titanium-carbon alloys just below the alpha transus (about 1600° F. or 875° C.), followed by quenching, gives especially strong and brittle material, because carbon solubility is high at that temperature, and the dissolved carbon can be retained in solution on quenching.

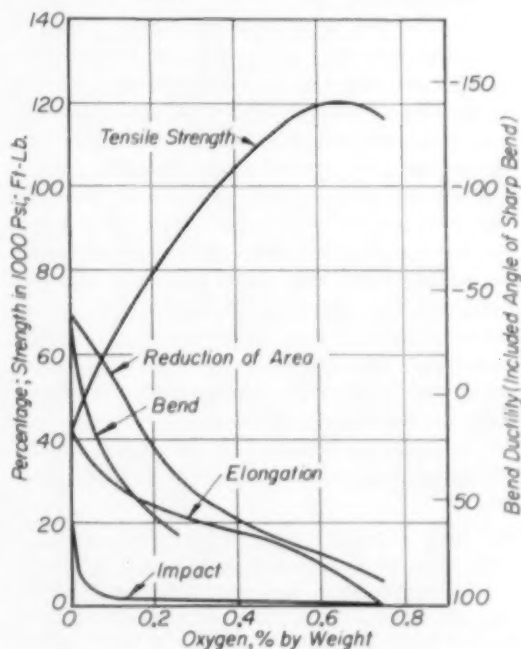
Introduction of a beta-stabilizing alloying element slightly decreases the solubility of carbon in both alpha and beta, expands the alpha-beta field to lower temperatures, and may markedly lower the peritectoid temperature. Carbon accelerates the transformation of beta to alpha—that is, decreases hardenability.

Hydrogen—The solubility of hydrogen in alpha titanium is extremely low at room temperature, about 0.002%. Titanium contains considerably more than this amount, unless specially vacuum-treated. Hydrogen-bearing alpha titanium slowly cooled from 610° F. (320° C.) or higher, as shown in Fig. 5, precipitates titanium

hydride (γ), which lowers toughness markedly but does not affect strength or ductility under slow loading. Quenching from above that temperature retains toughness temporarily, but the hydride precipitates in a matter of weeks at room temperature and the toughness of the aged alloy is lowered.

When both alpha and beta are present, hydrogen segregates strongly to beta. If the percentage of hydrogen in the beta is high enough, a type of embrittlement similar to hydrogen embrittlement in steel develops; ductility on slow loading disappears but impact toughness is not impaired. Frequently the embrittlement is not manifest at ordinary speeds of tensile testing at room temperature, but appears when loading is very slow or is sustained. The opposite effects of hydrogen on ductility and on toughness in alloys containing alpha and beta respectively have not been explained. The hydride precipitate which embrittles alpha can be seen metallographically, but the microscope has been of little value in identifying hydrogen embrittlement of the alpha-beta alloys.

Fig. 3—Effect of Oxygen on Mechanical Properties of High-Purity Titanium, Annealed at 1300 or 1560° F. (700 or 850° C.). Curves for nitrogen would be very close to the above if horizontal ordinate were doubled—that is, 0.2% oxygen equals 0.1 nitrogen. Impact tests on $\frac{1}{2}$ -size V-notch Charpy at 70° F. (Ref. 2, 3, 4 and 5)



The effect of hydrogen on the rate of beta to alpha transformation (hardenability) is not yet known.

Selection of Heat Treatment and Composition

When maximum hardness is needed for an application, the problem is to arrive at the peak of the curve in Fig. 1. This could be attained by quenching a lean alloy from the beta range—an alloy with just enough hardenability to permit reaching the peak. Rather close control of composition would then be necessary, and the maximum hardness would be reached only in thin sections, or at the surface of a thick section.

Another method would be to use a richer alloy, having enough hardenability so that it could be quenched from the beta range to a point at the left of the hardness peak and then temper it at

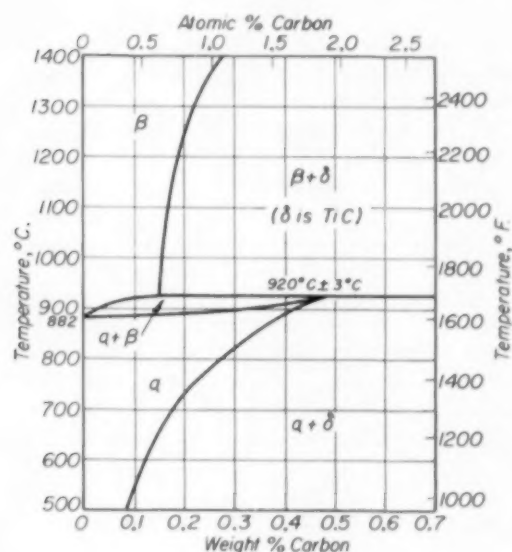


Fig. 4—Portion of Titanium-Carbon Equilibrium Diagram (Ref. 6)

600 to 900° F. (300 to 500° C.). By this means very high hardness would be obtained throughout the section. Close control of composition would not be needed; variations in composition could, if necessary, be compensated by adjusting the tempering temperature. The maximum hardness reported in titanium-base alloys is 625 Vickers (Ref. 8); 550 Vickers is more commonly attained. Material at this level is quite brittle. For very high strength with some ductility (200,000 psi. tensile strength, 5% elongation), the choice of composition can be on the same basis

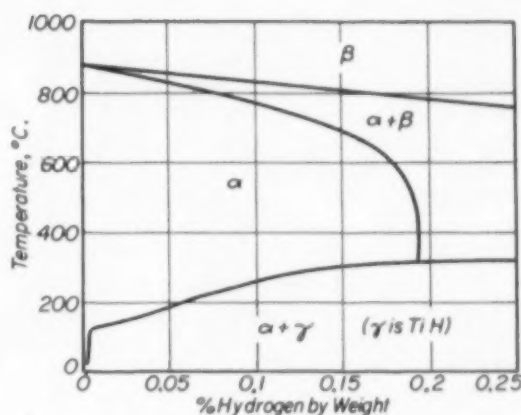


Fig. 5—Portion of Titanium-Hydrogen Equilibrium Diagram (Ref. 7)

as for maximum hardness. The material should be rolled or otherwise worked in the alpha-beta range, quenched, and tempered to the required strength (as shown on the right-hand side of the hardness peak). The solution temperature should preferably be below the beta transus and as low as possible consistent with attaining the required strength. For short times the tempering temperatures would be in the range of 850 to 1050° F. (450 to 550° C.).

For moderate strength with good toughness (yield strength 110,000 psi., tensile strength 130,000 psi., reduction of area 30%, V-notch Charpy impact energy 20 ft.-lb. at room temperature), there should be enough hardenability to reach high hardness in quenching a small section, but the hardenability need not be so high that soft beta would be retained. After working and solution treating in the alpha-beta range, good properties may be attained in several ways, such as cooling at moderate rates, isothermal transformation at low temperatures, or quenching and overaging.

For high toughness with some strength (65,000 psi. yield strength, 80,000 psi. tensile strength, 40 ft.-lb. V-notch Charpy at room temperature), alloys of low hardenability should be used. Solution treating in the alpha-beta region, then cooling, is perhaps the best treatment, though alloys of this type do not show much response to heat treatment.

For maximum toughness, unalloyed titanium should be used (40,000 psi. yield strength, 55,000 psi. tensile strength, 50 or more ft.-lb. Charpy at -40° C.). Such material is hardly heat treatable, but cooling from just below the beta transus will give the best toughness.

The choice of beta-stabilizing elements is a matter of convenience. The total amount of beta-stabilizing elements must be adjusted to provide the desired hardenability. Differences between elements are probably minor if impurities are kept out, except that for long-time service at elevated temperatures iron and chromium may be less desirable than other elements.

Aluminum up to 6% appears useful for providing strength with corresponding loss in ductility, but with little effect on heat treatment. Titanium alloyed with aluminum should be particularly valuable in those welding applications where minimum alteration in properties is desired at and alongside the joint.

The interstitial elements (C, N, O, H) are undesirable except where hardness is the only pertinent requirement. If high ductility or toughness is needed, these impurities must be held to a minimum.

Summary—The heat treatment of titanium alloys, as indicated in last month's *Metal Progress*, may be based upon a single curve relating hardness and brittleness with time of isothermal transformation, speed of quench, or time of tempering. Starting with metal in the beta phase, and holding at temperatures below the beta transus, an alloy will harden to 450 to 500 Vickers and become quite brittle as omega precipitates. After longer times at transformation temperature, the hardness will drop and toughness rise as beta plus omega changes to beta plus alpha. As shown in Fig. 1 of this article, the major effect of alloying elements in titanium is to retard these changes, thus increasing hardenability.

All of the alloying elements so far investigated

(except aluminum and the interstitials) stabilize beta and increase hardenability. Thus their effects are similar in kind, though different in degree. Alloying elements also add strength at the expense of ductility. Interstitial elements (carbon, nitrogen, oxygen, hydrogen) decrease ductility and toughness markedly. Aluminum strengthens titanium at the expense of ductility, with little effect on response to heat treatments.

Maximum hardness (450 to 550 Vickers) in thin sections or at the surface of thick sections may be obtained by quenching from the beta range an alloy that reaches peak hardness under these circumstances. Better reproducibility in thin sections, and high hardness throughout a thick section, may be obtained by quenching an alloy richer in beta-stabilizing elements, and then tempering at 600 to 900° F. (300 to 500° C.).

For some ductility with very high tensile strength (up to 200,000 psi.), the composition may be chosen similarly, the material worked in the alpha-beta range, quenched from this range, and then tempered beyond peak hardness.

For moderate strength with good toughness (tensile strength 130,000 psi., V-notch Charpy 20 ft.-lb. at room temperature) a composition that would reach peak hardness on quenching may be used. It should be worked and solution treated in the alpha-beta range, then cooled at moderate rates, isothermally transformed, or quenched and tempered well beyond peak hardness.

For maximum toughness, where only low strength is required, a composition of low hardenability should be used. Solution treating in the alpha-beta range, then cooling, is probably the best treatment.

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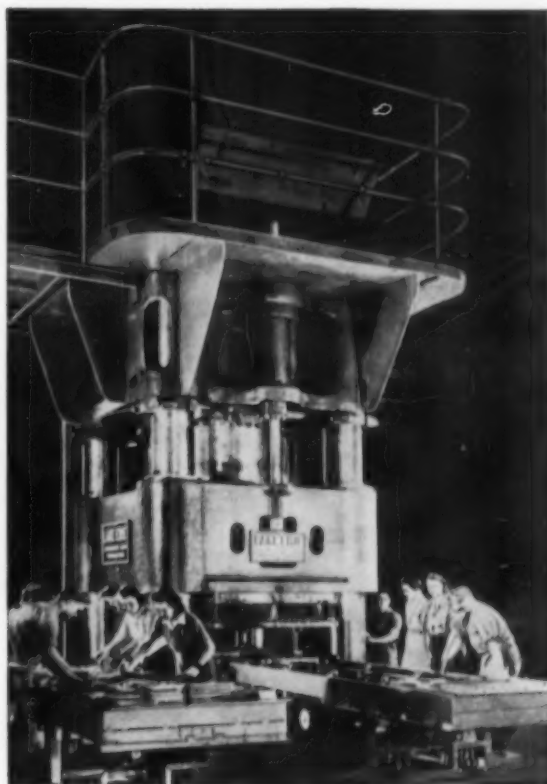
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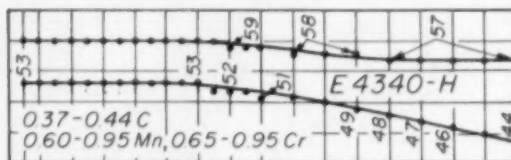
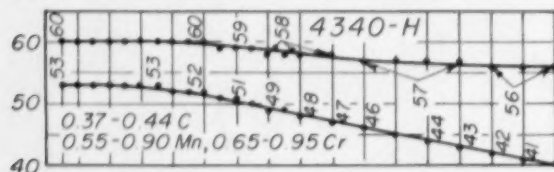
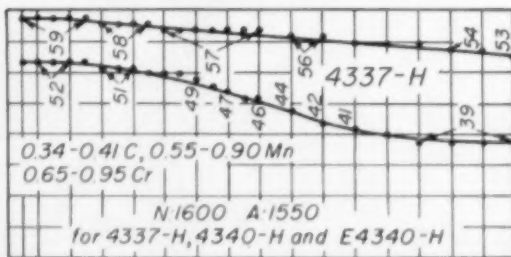
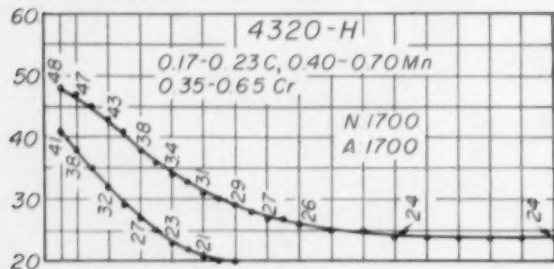
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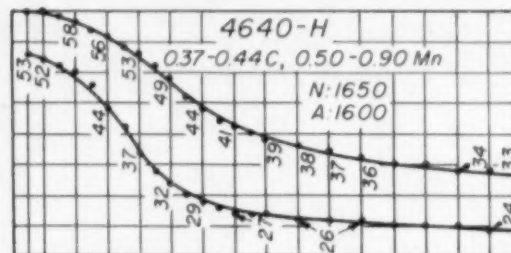
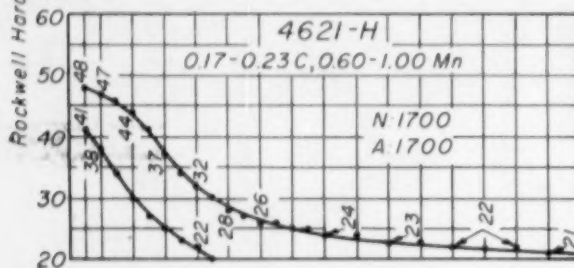
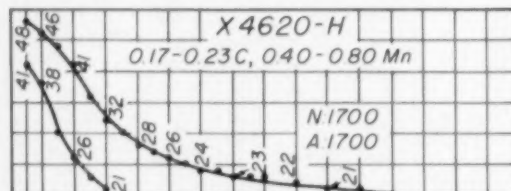
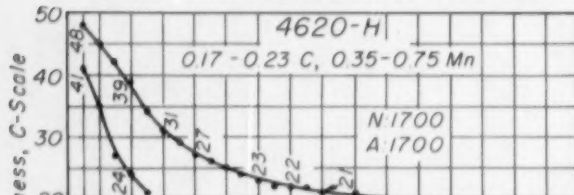
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Standard H-Steels, 4320-H to 4820-H

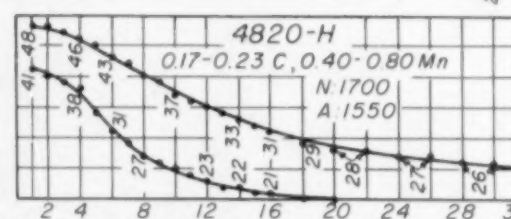
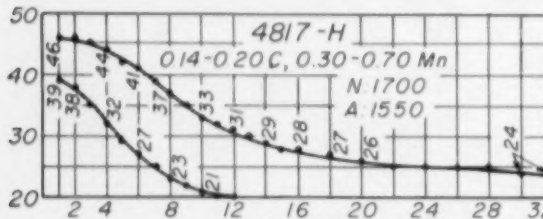
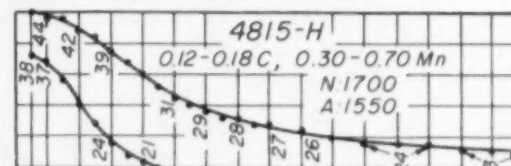
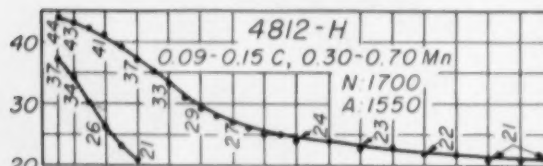
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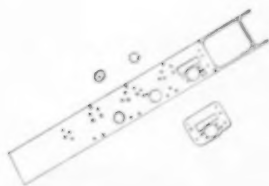
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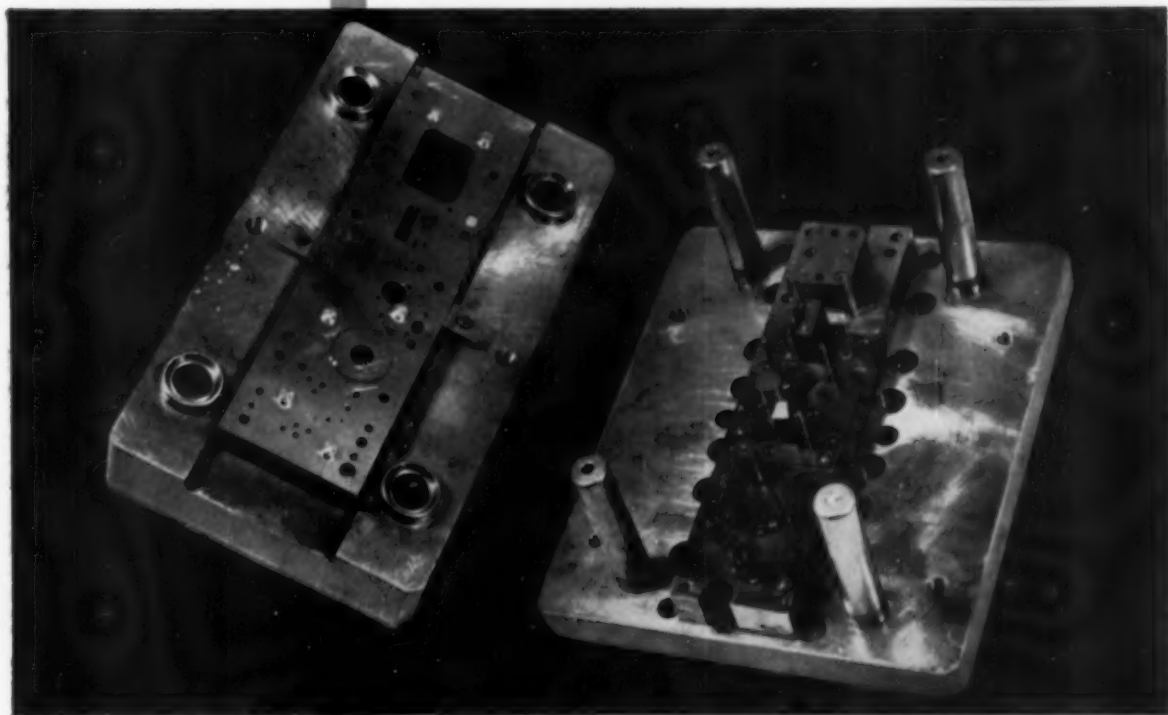
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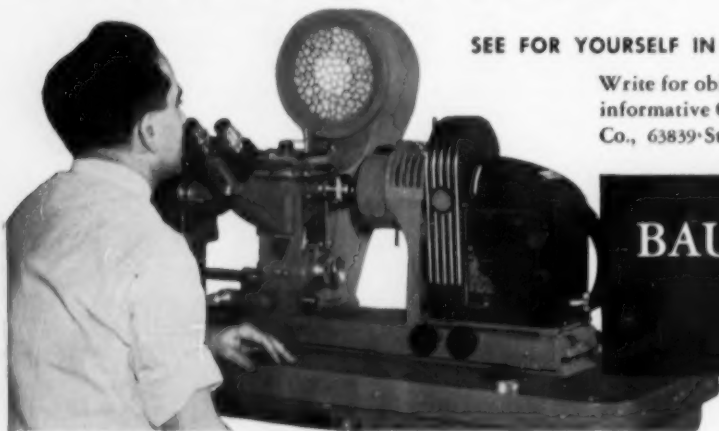
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Stress-Corrosion of Stainless Steels

By J. J. HEGER*

Studies of service failures and laboratory investigations have developed a better understanding of stress-corrosion. Some suggestions for preventing or minimizing it are offered, but a complete explanation of the mechanism of stress-corrosion cracking must await more fundamental information.

"STAINLESS STEELS" as defined by the American Iron and Steel Institute, include the alloys of iron and chromium, and of iron, chromium and nickel, that contain more than 5% chromium and at least 50% iron. Their "stainlessness" or corrosion resistance derives largely from the element chromium. Chromium increases the resistance of steel to corrosion in air as well as in other environments such as nitric acid.

Three theories have been advanced to explain why chromium imparts stainlessness or passivity

to steel: (a) the oxide film barrier theory, (b) the physically adsorbed gas theory, advanced by Fontana and Beck^{1†}, and (c) the electron configuration theory of Uhlig², which involves the chemi-adsorption of oxygen. Fortunately, these three theories have enough in common to permit a simplified concept of passivity—at least for the time being.

* Chief Research Engineer, Stainless Steel, U.S. Steel Corp., Pittsburgh.

†References listed on p. 116.



Fig. 1 — Stress-Corroded Surface of an 18-8 Pasteurizing Tank Exposed to Brine

Each theory states that passivity is confined to the surface of the metal and that at the surface, some combination of oxygen and chromium occurs. The theories differ in respect to the nature or form of this combination. One postulates that the oxygen is present as a physically adsorbed layer; the other, as a chemi-adsorbed layer; and the third, as the compound chromium oxide. For this discussion, the layer will be called a protective surface film involving oxygen and chromium, and thus no consideration need be given to its exact nature.

Corrosion encountered in the use of the stainless steels may be classified into four types:

General corrosion, involving complete breakdown of the protective film. The cause may be either lack of sufficient chromium in the steel or destruction of the protective film by an environment such as boiling 50% sulphuric acid.

Intergranular corrosion, caused by a breakdown of the protective film at the grain boundaries. It is believed that the grain-boundary layers become depleted in chromium because it becomes tied up in the grain boundaries as chromium carbide particles.

Pitting corrosion, resulting from localized breakdown of the protective film. The environments that cause pitting are "borderline"—if they were more active they would cause general corrosion, if less active, no corrosion.

Stress-corrosion, also resulting from a localized breakdown of the protective film. Corrosive attack is accelerated by stresses and cracking results. This type of corrosion will be discussed in this review.

Stress-Corrosion Service Failures

In comparison with other types of corrosion, stress-corrosion of stainless steel is a new subject. Its newness may be attributed not to the absence of stress-corrosion in the early uses of stainless steel, but rather that many early investigators did not recognize it. Since 1939 several service failures have been reported. Some of the corroding environments in which these failures were reported are listed below:

Sulphite liquor	Crude petroleum
Ethyl chloride	Marine atmosphere
Steam at 950° F.	Orange juice
City water	Inhibited calcium chloride
Humid air at 185° F.	Sulphurous acid
Dye liquor	Sulphuric acid
Brine	Boiling sodium hydroxide

The failure of stainless steel in sulphite liquor, described by Hoyt and Scheil³, one of the first reported, occurred in a 25% Cr, 11% Ni alloy which was fabricated into the main-way neck of a pulp digester. Metallographic examination disclosed the crack to be intergranular and also revealed the presence of an intergranular carbide precipitation. Moreover, a laboratory test showed the material to be susceptible to intergranular corrosion, which indicated that it had been heat treated improperly for the intended service.

The failure in ethyl chloride plus water occurred in 18-8 and 18-8 Mo thermocouple protection tubes of welded construction. The cracks were transgranular. In steam at 950° F. intergranular cracking occurred in 18-8 superheater

tubes. Both of these failures were reported by Hodge and Miller⁴.

The next three environments listed above were described by Ellis⁵. The failure in city water occurred in two 18-8 coffee pots, of cold formed and welded construction; cracking was transgranular. Transgranular cracking also was observed in the failure of 18-8 in humid air at 185° F.; this was in a liner for a wool-conditioning unit of welded construction. In neither instance was the cracking associated with the heat-affected zone of the weld. The failure in dye liquor occurred in 18-8 that was cold formed and welded. Again, cracking was transgranular.

Rees⁶ reported stress-corrosion cracking of cold drawn 18-8 wire used as a filter in a pipeline carrying crude oil, and gave laboratory evidence to support his belief that the corroding agent was hydrogen sulphide dissolved in the oil.

Although the reason is not completely understood, stress-corrosion in stainless steels appears to be confined largely to the austenitic alloys. Indeed, few service failures of the ferritic alloys have been reported in the literature; and Scheil⁷ says that they are practically immune. On the other hand, Ffield⁸ tested various modifications of the 12 to 16% Cr steels and found that, without exception, these steels could be made to stress-crack. Later, Uhlig⁹ described failure by cracking of the ferritic steels as probably caused by hydrogen embrittlement. Perhaps one reason for the lack of reported service failures of the ferritic alloys is that they were explained by other mechanisms such as fatigue or quench cracking.

The next group of service failures to be described and illustrated were investigated in the laboratories of U. S. Steel Corp. over a six-year period. Because of the widespread belief that chlorides or halides must be present before stress-corrosion cracking will occur in stainless steels, the environments in which they occurred are classified as: (a) environments definitely containing chlorides or halides; (b) environments in which the presence of chlorides or halides was suspected; (c) environments containing no chlorides or halides.

Environments Containing Chlorides — The failure illustrated in Fig. 1 occurred in a jacketed pasteurizing tank, with inner shell constructed of cold formed and welded 18-8, and outer shell of carbon steel. One surface of the 18-8 was exposed to milk and the other to brine. After ten years service the stainless steel failed by cracking.

No corrosion had occurred on the milk side of the stainless but pitting occurred on the brine side. The cracking, which was well removed from the heat-affected zone of the weld, was transgranular, typical of a stress-corrosion failure. Another jacketed milk tank of welded construction failed in a similar manner, with the additional interesting feature shown in Fig. 2 that although there was evidence of intergranular carbide precipitation, the cracking that occurred was transgranular.

Another example was a steam-jacketed evaporation dish constructed of cold formed and welded 18-8 Mo, used to evaporate a slightly alkaline solution of calcium chloride from a con-

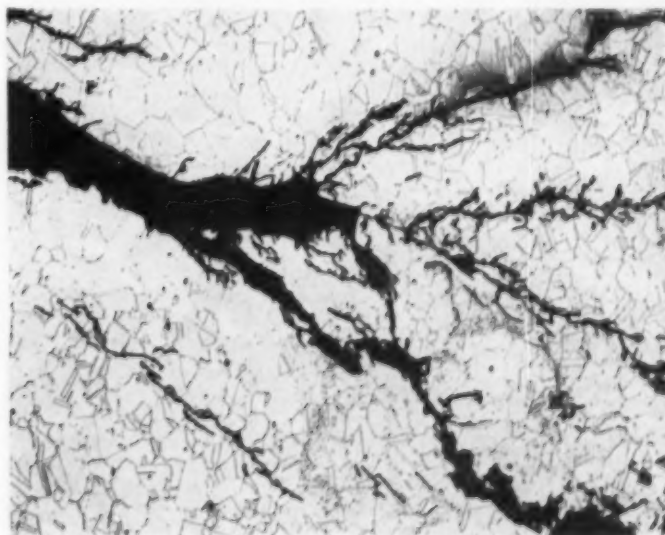


Fig. 2 — Brine Side of Jacketed Milk Tank Showing Transgranular Stress-Corrosion Cracking Through Areas Containing Intergranular Carbides. Sodium cyanide etch, 100×

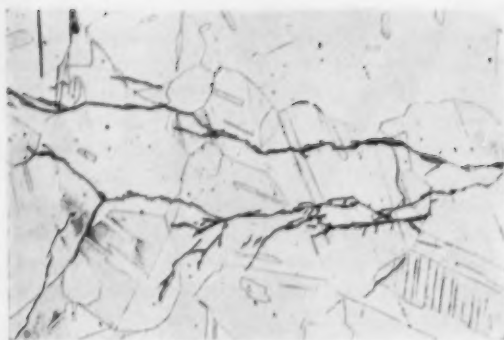


Fig. 3 - Transgranular Cracks and Strain Lines in 18-8 Mo Evaporation Dish Used With Calcium Chloride Solution. Oxalic acid etch, 50X



Fig. 4 - Sketch of Stress-Corrosion Cracking in $\frac{1}{2}$ -In. Thick Welded Section of 18-8

centration of 25% to 50%. During evaporation, the temperature increased from 122 to 302° F. Cracking occurred near the weld 60 days after installation of the dishes (Fig. 3). Examination revealed that pitting had occurred, the cracking was transgranular, and the grains exhibited strain lines. Probably the strain lines resulted from residual stresses originating during fabrication, although the thermal cycle employed during operation may have exaggerated their effect.

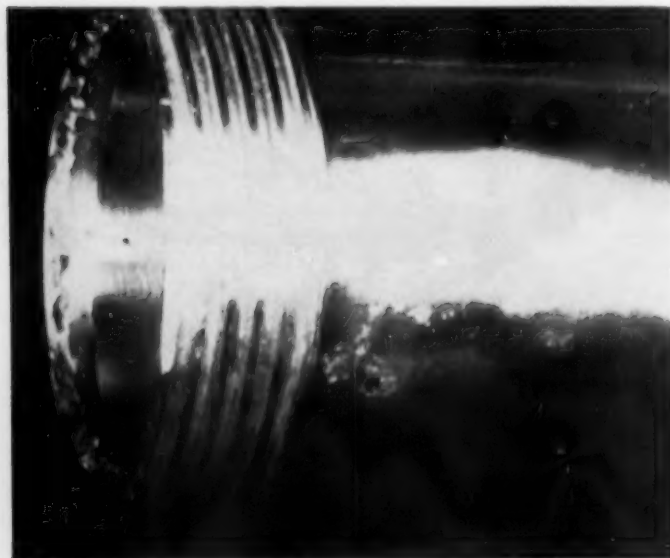


Figure 5 illustrates pitting and cracking near a threaded ferrule welded to a cold bent 18-8 stainless tube. This tube was used to convey orange juice. Cracking originated on the inside of the tube, and was transgranular.

Textile dyes provided the environment for the next failure — a drum of cold formed and welded 18-8 that served as a reel over which wet fabric moved; it was above the dye vat and exposed to dye vapors as well as solution. Composition of the solution was not known, except that it contained a little sul-

The inner liner of a cold formed and welded 18-8 coffee urn, exposed to city water at temperatures not exceeding 212° F., failed by transgranular cracking, even in those locations which showed intergranular carbide precipitation at a higher magnification.

Environments in Which Chlorides Were Suspected — In the next five failures to be considered the exact natures of the environments were not known but they were suspected to contain chlorides or halides.

In this category an 18-8 welded tank cracked, and the cracking propagated from the weld metal into the parent metal. Although intergranular carbide precipitation had occurred, the cracking

was transgranular. A surface leach of this sample disclosed the presence of chlorides.

Figure 4 is a sketch of stress-corrosion cracking in a horizontal milk-storage tank fabricated of $\frac{1}{2}$ -in. 18-8; as shown, the cracking occurred in a weld which had been repaired, and in the parent metal near the weld deposit. Where carbide precipitation had occurred, the cracking was intergranular; where there was no carbide precipitation it was transgranular.

Fig. 5 - Pitting and Cracking Near a Threaded Ferrule Welded to a Cold Bent 18-8 Tube

phuric acid. The cracking was transgranular and was outside the weld areas. The failure occurred after one year of service.

Figure 6 illustrates stress-corrosion cracking after three months' service in a cold formed and spot welded 18-8 compressor rotor (described in more detail by Davis¹⁰). The cracks were transgranular and transverse to the residual tensile stress caused by the spot welds (Fig. 7).

Environments Containing no Chlorides—The next two failures to be described occurred in environments that are believed to have contained no chlorides.

One occurred in a cold formed 18-8 Ch bellows-type expansion joint. Composition of the gas carried through the inner sleeve of this joint was 0.1% carbon dioxide, 0.7% hydrocarbons, 0.4% carbon dioxide, 0.3% oxygen, 5 to 6% hydrogen, and balance nitrogen. The gas was under 100 psi.

pressure and at a maximum temperature of 400° F. Transgranular failure through a ½-in. wall occurred in less than 60 days. Pitting was observed on the inside of the joint near the cracks. Pitting and perforation, but no cracking, occurred in the sleeve. Probably, gas leaked in between the sleeve and the joint and some of the impurities in the gas condensed. The condensate evidently contained either H_2SO_4 or H_2SO_3 because a residue scraped from the joint contained sulphur. Neither chlorides nor halides were found. As illustrated by Fig. 8 the cracking was transgranular, and at least some grew from a pit.

Figure 9 is a sample of ½-in. thick stainless steel Type 309 (25-12) which was removed from a welded kettle. This kettle, which was used to hold molten sodium hydroxide at 700° F., failed by cracking near the welds and around stress-raisers. The cracks were transgranular, even in those areas containing intergranular carbide precipitation (Fig. 10). No other attack, such as pitting, was observed.

Laboratory Investigations

Laboratory investigations on stress-corrosion of stainless steel have been directed at studying the environments involved and

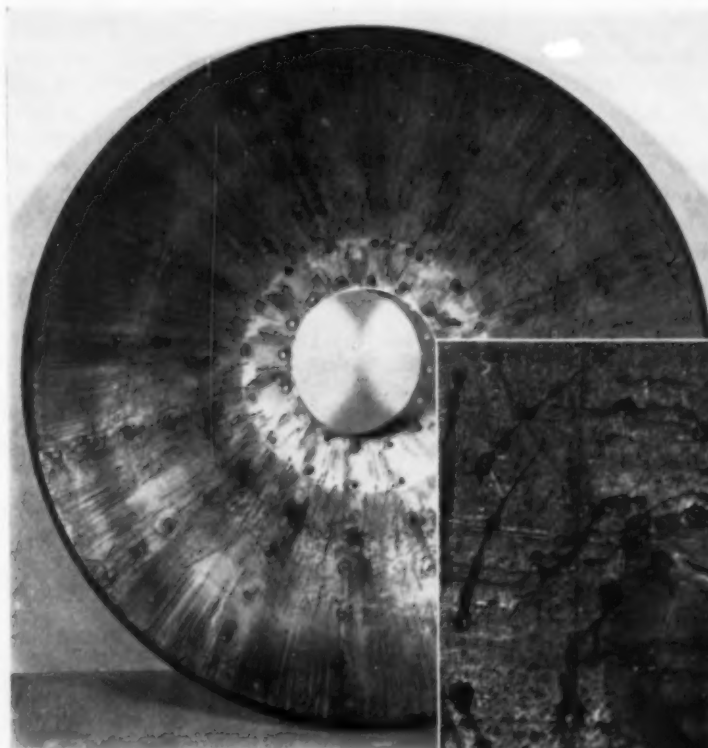
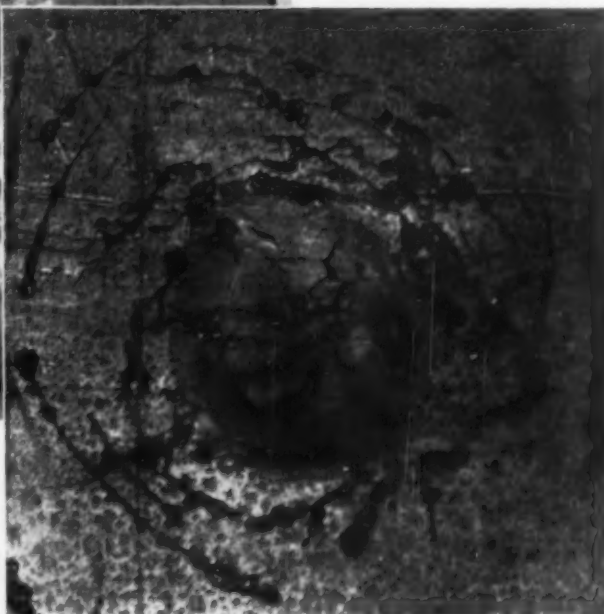


Fig. 6—Configuration of Stress-Corrosion Cracks Around Rivet Holes and Spot Welds. Approximately one-fourth size

Fig. 7—Enlarged View of Circumferential Cracking Around Spot Weld of Rotor Shown in Fig. 6. 6×



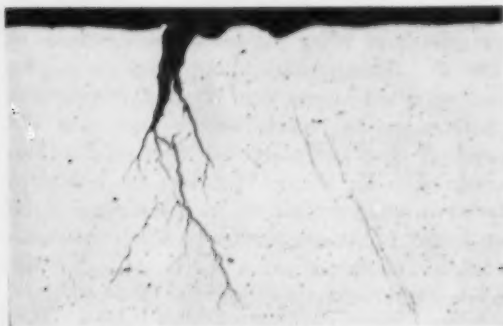


Fig. 8 - Transgranular Cracks in Stainless Steel Expansion Joint Appear to Propagate From a Pit on the Inside Surface. No chlorides present in environment

the stresses needed to cause cracking. Environments which caused cracking in laboratory tests are:

- Ammonium chloride
- Calcium chloride
- Cobalt chloride
- Lithium chloride
- Magnesium chloride
- Mercuric chloride
- Sodium chloride
- Zinc chloride
- Moist hydrogen sulphide

With one exception all of the solutions were chlorides and the belief therefore arose that chloride-containing environments were the *only* culprits. The cracking in moist hydrogen sulphide reported by Rees⁶ in cold drawn 18-8 and hardened 12% Cr steel wire certainly refutes this idea.

All investigators agree that tensile stresses are necessary to cause cracking. Franks, Binder, and Brown¹¹ report a "limiting" or "threshold" stress, which must be exceeded before cracking may occur, as illustrated in Fig. 11. It will be noted that the stress-time curve for stress-corrosion cracking resembles the S-N curve for fatigue, and that the "limiting" or "threshold" stress varies with the prior treatment of the metal. Undoubtedly, this stress also varies with environment.

Prevention of Stress-Corrosion

Inasmuch as stress-corrosion is caused by the simultaneous action of both stress and corrosion, a reduction in the intensity of either factor should reduce, if not entirely prevent such failures. In addition, selection of the proper alloy for the environment may minimize stress-corrosion cracking.

Stresses originating during service may be modified by changes in the design and operation of equipment. For example, the causes of

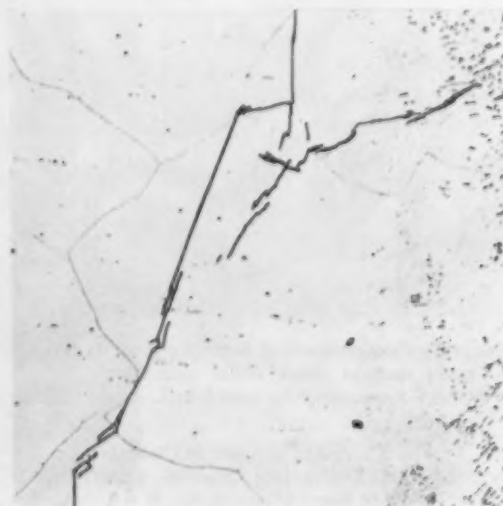


Fig. 9 - Sample of 1/2-In. Plate Removed From a Defective 25-12 Cr-Ni Kettle. Note cracking near weld and around tapered holes at upper edge. Drill hole on surface was to provide drillings for chemical analysis

mechanical vibration might be eliminated or modified or suitable expansion joints used to minimize the effects of thermal fluctuation.

Residual stresses seem to cause a majority of the stress-corrosion failures. They result from cold forming and welding during fabrication.

Fig. 10 - Transgranular Crack Through Area Adjacent to Weld in Sample Shown in Fig. 9. Note intergranular carbide precipitation. Sodium cyanide etch, 100×



and may be removed by stress-relieving heat treatments. Certainly, stress-relieving after cold forming and welding is desirable.

Inasmuch as the loads causing the damage induce tensile stresses, Krivobok¹² has suggested that the surfaces of the metal be compressed by shot-peening. Certainly, this is a worth-while suggestion.

The effect of the corroding environment may be modified by the use of inhibitors or by cathodic protection. Inhibitors such as chromates and phosphates minimize the localized type of attack. For example, in the pasteurizing tank illustrated in Fig. 1 a chromate inhibitor was used; although stress-corrosion did occur, the service life of the metal was ten years. Without an inhibitor failure might have occurred much sooner.

Cathodic protection of stainless against stress-corrosion was suggested by Mears, Brown, and Dix¹³. Their findings are summarized in Table I, which lists the metals which, when connected electrically with stainless steel, prevent it from cracking in a sodium chloride solution. Many of the jacketed vessels described above are examples of stainless steel connected to carbon steel, and in all of these vessels cracking did not occur before seven to ten years of service. Perhaps the reason that cracking occurred at all was that corrosion products accumulated on the carbon steel, thus lowering the difference in electrical potential between the two steels and thereby decreasing the intensity of the cathodic protection.

Since stress-corrosion results in a localized breakdown of the protective film, selection of the proper stainless alloy to resist localized breakdown may be one remedy. For example, many corroding environments that attack 18-8 stainless steel do not attack 18-8 with suitable additions of molybdenum. In such environments use of 18-8 Mo may minimize the danger of cracking.

Since the intergranular type of stress-corrosion cracking is associated with the intergranular precipitation of chromium carbides, additions of columbium or titanium in amounts sufficient to stabilize

Table I — Effect of Contact With Dissimilar Metals on Stress-Corrosion of 18-8 Stainless Steel*

CONTACTING METAL	POTENTIAL DIFFERENCE	TIME IN TEST
Zinc	-0.92	(a)
Aluminum	-0.76	(a)
Cadmium	-0.69	(a)
Mild steel	-0.53	(a)
Lead	-0.49	(a)
5 Cr steel	-0.39	(a)
13 Cr steel	-0.21	(a)
Copper	-0.10	(a)
Cupronickel (70 Cu, 30 Ni)	-0.03	15 days (b)
18-8 stainless steel	-0.00	10 (b)
Nickel	+0.07	10 (b)
Platinum	+0.29	4 (b)

*Solution used was 100 g. per liter NaCl + 9 g. per liter H₂O₂. The attack was undermining corrosion with little evidence of surface attack. Cracks developed in the stressed specimens at regions where this highly localized attack was severe.

(a) No visible cracks in 55 days.

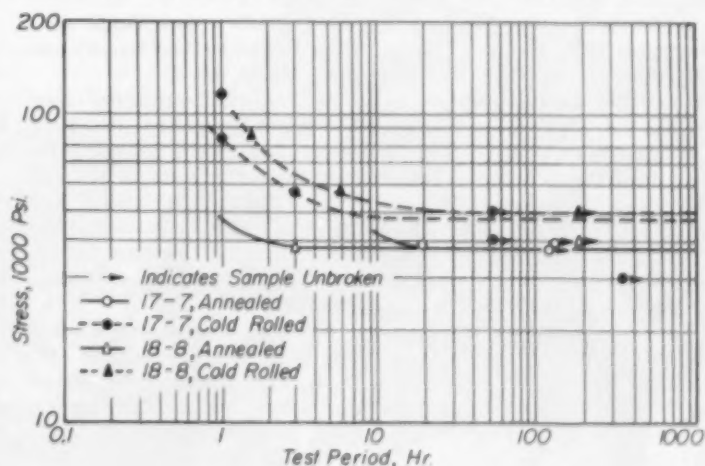
(b) Time to first visible crack.

the carbon or the use of the low-carbon (0.03% C max.) stainless steels should prevent this type of cracking.

Summary

The service experiences and laboratory investigations just described permit some generalization about the conditions under which stress-corrosion cracking will occur in stainless steel.

Fig. 11 — Results of Stress-Corrosion Tests on 17-7 and 18-8 Stainless in Boiling 24% Solution of MgCl₂. Yield strength of 17-7 was 28,000 psi. annealed, and 157,000 psi. cold rolled; of 18-8, 26,000 psi. annealed, and 125,000 psi. cold rolled. (According to Franks, Binder and Brown, Ref. 11)



Obviously, the metal has to be simultaneously subjected to stresses and exposed to a corroding environment. Tensile stresses are needed, and these may be either applied or residual. Residual stresses appear to have caused most of the stress-corrosion failures encountered during service. Indeed, in practically every failure discussed, the stainless steel was in the cold formed and welded condition, and thus subjected to severe residual stresses. Therefore, the observation made by Dix¹⁴ that no stress-corrosion cracking in aluminum alloys is caused by operational stresses alone, also applies to the stainless steels. The exception to this is the intergranular failure associated with poor structural condition of the metal. Applied stress, either static or the dynamic stresses resulting from thermal or mechanical fluctuations, may intensify residual stress.

Recently Edelenau¹⁵ suggested that the transgranular stress-corrosion cracking in austenitic stainless steels is due to preferential attack on small quantities of quasi-martensite, which form in the steel during straining. However, evidence of stress-corrosion in Types 309 and 310 stainless steels which show no tendency to form quasi-

martensite suggests that this phenomenon alone is not responsible.

Generally, stress-corrosion of stainless steels is believed to occur only in environments containing chlorides. This belief has some support, inasmuch as practically every environment in which cracking has occurred has contained at least a trace of chlorides. Nevertheless, failures have been reported in molten sodium hydroxide, sulphuric acid, and moist hydrogen sulphide, which contained no chlorides. Undoubtedly, these environments also cause a localized breakdown in the protective film similar to that caused by the chloride environments.

Briefly, stress-corrosion cracking can occur in stainless steel when it is subject to a sufficiently high stress and simultaneously exposed to an environment whose nature causes localized attack. Stress-corrosion has not been observed in those environments which cause rapid general attack. Therefore, like pitting and intergranular corrosion, stress-corrosion appears to be associated with a localized breakdown of the protective film, and this breakdown is accelerated by applied or residual stresses. ●

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
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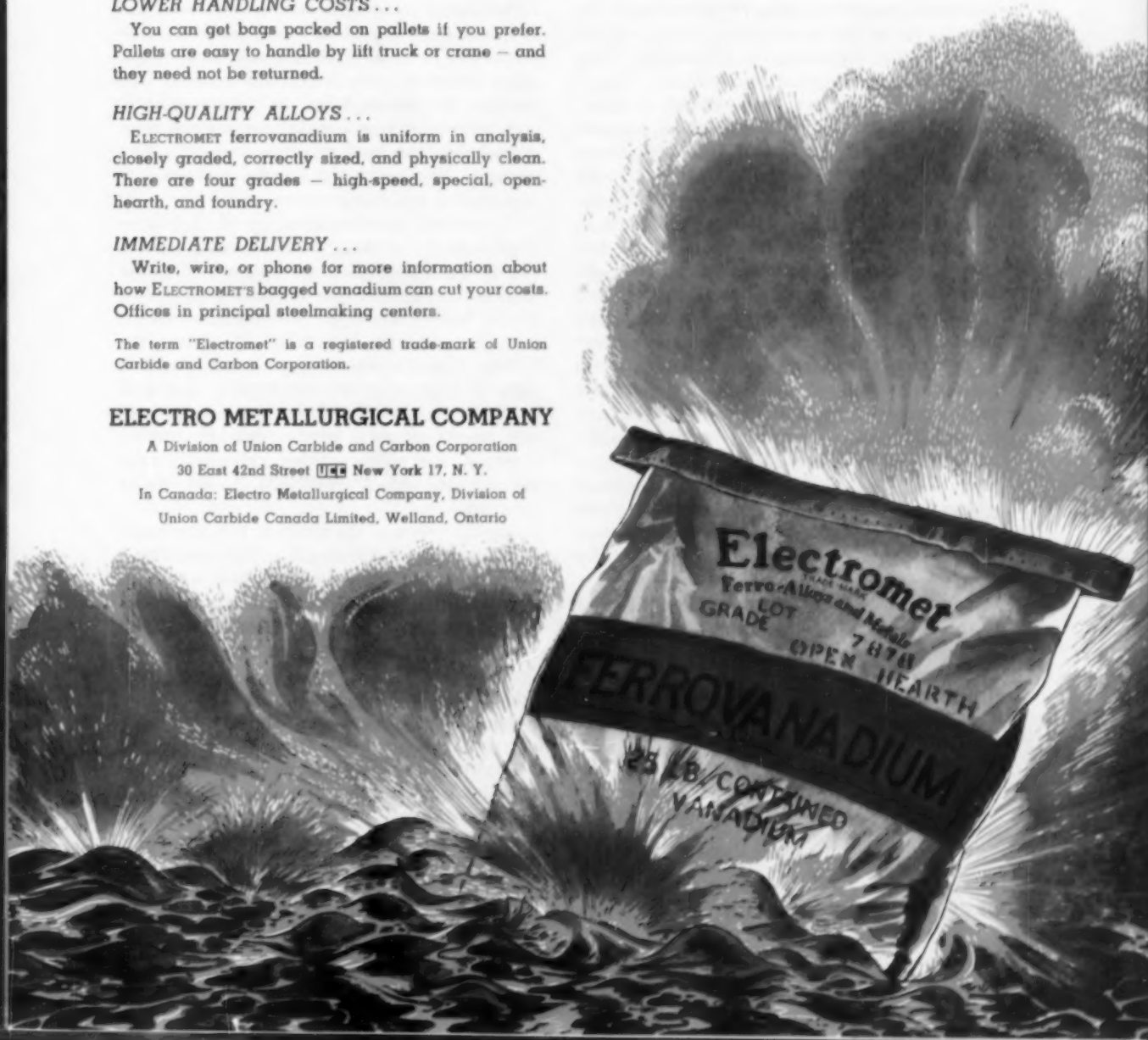
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To Preheat or Not

Rebuttal

By W. S. PELLINI*

MR. LIEDHOLM's interest in the report of this investigation and the excellent digest of the report he has prepared for *Metal Progress* are appreciated. However, exception is taken to certain concluding remarks pertaining to the significance of the investigation and to a broad generalization regarding the philosophy of research workers in report preparation.

Mr. Liedholm states, "It is difficult to accept the thought that these ingenious experiments would have resulted only in the essentially negative conclusions reported by the authors." To the contrary, the results were quite positive and already have resulted in considerable savings to the U.S. Navy and indirectly to the taxpayers. The investigations were aimed at resolving the need for expensive preheat operations in welding of high-pressure steam lines. Prior to this research it was customary to apply preheat of 600° F. to the chromium-molybdenum steam piping to be welded and to hold the preheat until stress-relieving operations could be performed. This was an expensive operation, in the maze of piping characteristic of shipboard systems; also, it was difficult for welders to operate efficiently and still produce high-quality welds under such conditions of excessive temperatures. Sometimes the use of preheat was dictated by restraint conditions; that is, factors which the welding engineers could evaluate. However, most of the time the use of high preheats was based on what our welding engineers choose to describe as an area of "metallurgical witchcraft", denoting that in the absence of applicable metallurgical data, guess work and expensive "better be safe" attitudes must prevail.

The report is positive in placing the welding engineer at ease insofar as metallurgy is concerned. Simply stated, preheats as high as 600° F.

do not affect the nature of transformations. So, henceforth, no money will be spent by the U.S. Navy on preheats except when they are needed for relieving restraint conditions (non-metallurgical reasons). Moreover, no money will be spent to hold preheats until postheat treatments may be applied. The message to the welding engineer is quite clear and positive. The research job accomplished its purpose and its cost to the Navy was repaid many times over, even before the final report was issued. This seems to be a good test for the evaluation of any applied research program.

The second question raised by Mr. Liedholm applies to the philosophy of research reports. He states, "A description of the practical equipment and procedures used in welding pipe joints would have enabled an interested reader to speculate over the possibility of putting the findings to more productive use", and, "As often seems to happen in our contemporary industrial research, the planning, design and execution of experiments appear to have received the greater share of the author's time and efforts than the analysis and interpretation of the results obtained."

Any discussion of the merits of this conclusion must hinge on what is meant by "interpretation". A clear-cut metallurgical interpretation was given in the report. It seems that this is not considered sufficient inasmuch as a description of practical equipment and welding procedures, based on the findings of the investigation, was not provided. Therefore, the real question that is raised pertains to the duties of metallurgists in instances such as this. Is it the province of metallurgists to dissertate on practical equipment and procedures for welding pipe? We are of the opinion that it is as unrealistic to expect the metallurgist to delve into this area of specialization as it is

(Continued on p. 122)

*Superintendent, Metallurgy Div., Naval Research Laboratory, Washington, D.C.

In his review "Transformation During Welding"[†] (*Metal Progress* for August 1954, p. 162), Mr. Liedholm stated that the conclusion the authors present in their report was "essentially negative". This and two comments made by the reviewer brought a rebuttal from one of the authors of the report. So, the rebuttal and Mr. Liedholm's rejoinder to it are presented herewith.

Rejoinder

By C. A. LIEDHOLM*

MR. PELLINI has taken exception to some of the concluding remarks in my review of his report. If I have understood Mr. Pellini correctly, the statements to which he referred can be summarized briefly as follows:

1. The conclusions of Mr. Pellini's excellent report were essentially negative.
2. It would have been valuable to an interested reader to have a description of the equipment and procedures used and their evaluation on the basis of the findings of the investigation.
3. Contemporary industrial research often devotes proportionally too little time to the interpretation of experimental results.

I am grateful to Mr. Pellini and to the Editor of *Metal Progress* for the opportunity of presenting in somewhat greater detail the reasons for my remarks.

The title of the paper, "Transformation of Cr-Mo Steels During Welding; Cooling Transformations of Two Chromium-Molybdenum Steels Under Welding Conditions Including Preheat", seemed to indicate a broader scope than whether to preheat or not to preheat particular types of welds at 600° F. The data, in keeping with the title, seemed to present challenging possibilities of developing new and improved methods of postheating welds or modifying their cooling cycles to insure them against cracking. An average reader could not be expected to sense that the conclusions were restricted by the difficulties involved in shipboard welding. To him, the conclusions derived from all the available information tend to suggest the mouse born of the mountain, from the standpoint of welding technique, if not from the standpoint of the savings in direct production costs.

I called the conclusions negative because they are a license to eliminate an established precaution (600° F. preheat) instead of providing the better substitute that was anticipated.

Granted that with steel of so low a carbon content it may have been safe to dispense with preheating, why was the remark injected that "This should not be interpreted to mean that preheats of 600° F. or less are not useful; certainly under high restraint conditions preheat quite frequently will eliminate cracking of root passes." Many readers are likely to disregard or overlook this statement, especially those who consider preheating as being justified not on "applicable metallurgical data" but on "metallurgical witchcraft". This is the group whose main interest is speed of production and simplicity of operation. Many members of this group will be likely to use Mr. Pellini's article as an argument against the continued use of preheat practice or against its introduction, making it harder for metallurgists elsewhere to convince the skeptics.

The second statement was not meant to launch any discussion about the philosophy of research reports. Inasmuch as I sensed that practical difficulties may have prevented a more constructive use of the data so as to satisfy requirements for safety and quality and I suspected that some information might have been withheld for policy reasons, I believed that the description which was omitted might have resolved some of the disappointment in the conclusions of the magnificent investigation.

Mr. Pellini discussed the philosophy of research reports and related it to the question whether it be "the province of metallurgists to dissertate on practical equipment and procedures for welding pipe".

I am all for development of basic knowledge

*Senior Engineer, Atomic Power Div., Westinghouse Electric Corp., Pittsburgh.

†Digest of "Transformation of Cr-Mo Steels During Welding", by W. R. Apblett, R. P. Dunphy and W. S. Pellini, *Welding Journal*, January 1954, Vol. 33, p. 575-645.

Preheat—Rejoinder . . .

and believe that my personal record proves it, but my practical experience has established the firm conviction that the metallurgist whose province is limited by what he can observe in the microscope or demonstrate through laboratory experiments, or considers his duties to end with the delivery of a report to a "customer", deprives himself of the

intimate contact with important realities the knowledge of which would help him increase the practical value of his work; and that he relinquishes responsibilities that, eventually, he would be best equipped to fill. I do not believe that any other engineering background develops such appreciation of the importance of detail, or the insight and intuition concerning the invisible processes occurring in the metal during heating or cooling, to

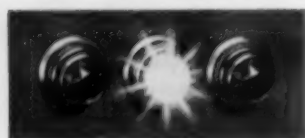
the same extent as the metallurgical background. Therefore, the metallurgist should actively follow through his recommended applications of nature's metallurgical laws to industrial processes, thereby also subjecting his theoretical approach to the broadening influence of contact with practical obstacles. Metallurgical theory must be coordinated with industrial metallurgical practice and the metallurgist should be an actively interested member of the team of coordinators, the better to serve the broad objectives of his work. Specialization tends to narrow a man's horizon and is justifiable mainly because time is too short.

My third statement is more than a critical remark; it is an appeal to those who are in a position to do something about it to encourage and promote the analytical part of industrial laboratory work. It is justified on the basis of my personal experience and observations. As a rule, the pressure of assignments flowing into an industrial laboratory, some of which may even be undertaken for psychological rather than technical reasons, and the demand for quick answers or maximum speed interfere with — or even preclude — the thorough analysis which becomes most profitable in the end.

For example, some years ago I was fortunate in being able to derive from some tests a considerable volume of excellent data on continuous cooling transformation. My daily duties and those of my associates prevented us from doing more with this data than to obtain the fundamental information we needed to heat treat propeller blades. Later, experiments of the same kind were made by Krainer and Kroneis of the University of Leoben, Austria. Their painstaking analysis of data no better than ours enabled them to determine rates of nucleation, incubation times and rates of growth for different cooling conditions, thereby giving them a deeper and far more revealing insight into the mechanisms of continuous cooling transformation than we could obtain from our brief analysis of the data.

My "final generalization" is certainly no accusation of negligence, but I cannot agree that spectacular growth is proof of perfection. It is to the better interest of industrial research to examine itself for shortcomings.

C. A. LIEBHOLM






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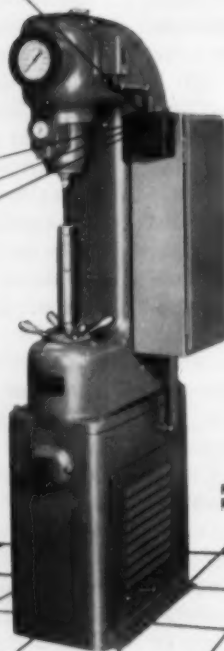
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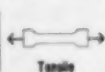
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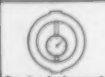
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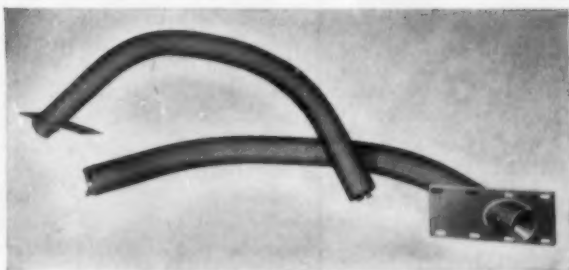


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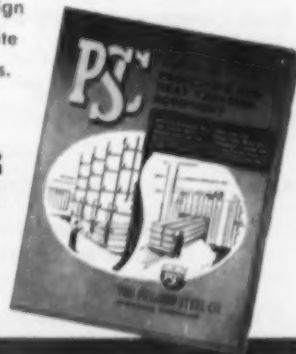
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to expect the welding engineer to resolve questions of metallurgical nature. The welding engineers as "customers" of this investigation expected a broad and basic metallurgical answer to a metallurgical problem, which they in turn could translate to practice. Such translations are usually not simple and must take into account economic factors, characteristics of welding equipment, and considerations of a similar nature.

Our philosophy in approaching complex technological problems is

well illustrated by the report being discussed. This philosophy is to search for the answer through studies aimed at establishing basic knowledge. In keeping with this philosophy, the approach to the preheat problem was by determining continuous cooling transformations rather than by conducting large-scale welding trials using different welding procedures, thicknesses of pipe, preheats, and electrodes. The basic transformation diagrams provided the answer at a minimum of cost and effort. Nor was there any need to couch the answer in terms of the above-mentioned welding variables. It is quite

clear that no variations in welding practices which utilize preheats of less than 1000° F. will have any effect on the metallurgical transformations which occur in the heat-affected zone. Preheats of 1000° F. are not practical for shipboard welding, and the conditions which permit such preheats are best decided by welding engineers.

The desire of metallurgical research groups to provide basic answers to such complex problems should be defended and encouraged. The value of a basic answer lies in the fact that it provides a basis for evaluating the problem on a broad front and is not restricted in its significance to a specific set of conditions. Direct welding trials, for example, provide answers which often have the misleading appearance of being more practical because the data are presented in terms of recognizable welding conditions. All too often the significance of the data does not extend beyond the specific conditions of the test.

Mr. Liedholm's conclusions regarding reports of our contemporary industrial research are not justified. Metallurgists as specialists should not be expected to provide out-of-their line interpretations. That our research investigators refrain from this is a sign of our times inasmuch as specialization is a mark of our contemporary industrial research. In final analysis, all industrial research has a "customer" in the background and it is inconceivable that the spectacular growth of industrial research could have occurred with research groups so negligent of the customer's desires as would be concluded from Mr. Liedholm's final generalization.

W. S. PELLINI

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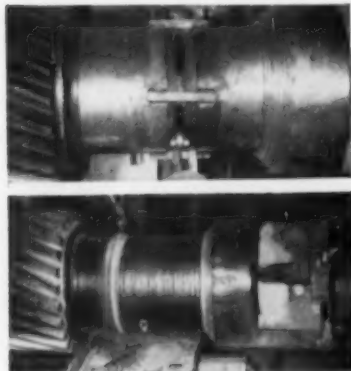
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A southern manufacturer of steel products reports a production increase of 40 per cent and a reduction in total unit cost of 30 per cent with the introduction of powder-starting in an oxy-acetylene cut-off operation. It was estimated that a standard cutting blowpipe required a minimum of 18 seconds to

start cuts in 6-in. steel gothic squares. Powder-starting was added by attaching a powder-cutting adapter to the standard oxy-acetylene cutting blowpipe. Now, cuts are started in 1 1/2 to 3 seconds.

In powder-cutting an iron-rich powder is added to the oxygen stream to develop an extremely hot cutting flame. The powder-cutting process makes the cutting of stainless steels, cast iron, or non-ferrous metals an efficient, economical operation.

Ask your nearest LINDE representative how you can increase production and lower costs with powder-starting and other powder-cutting processes.

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Personal Mention



Carl A. Liedholm

CARL A. LIEDHOLM has joined the Atomic Power Div. of Westinghouse Electric Corp., Pittsburgh, as senior engineer for the apparatus subdivision. Mr. Liedholm has contributed to *Metal Progress* notably on the necessary controls for die quenching—principally systematic studies of transformation of alloy steels during continuous cooling at widely varying rates. Swedish-born and educated, he was for ten years prior to World War II a metallurgist for Jessop Steel Co. in Washington, Pa. During his period, in 1935, he also graduated from Carnegie Institute of Technology with a bachelor of science degree in metallurgical engineering. During the war, Mr. Liedholm was chief engineering metallurgist for Curtiss-Wright's Propeller Div. in Caldwell, N. J. From 1950 to 1953 he directed research into rock drills for Sandvik Steel Works in Sweden, and from 1953 to the end of 1954 was research metallurgist for Rem-Cru Titanium, Inc., in Midland, Pa.

Frank Weir has been appointed assistant general sales manager of Harbison-Walker Refractories Co., Pittsburgh. He had been the Pittsburgh district sales manager since 1949. Mr. Weir has been associated with the company since 1923, serving in sales positions in New York, Boston, Buffalo and St. Louis.



John Herbert Hollomon

JOHN HERBERT HOLLOMON, manager of the metallurgy department, General Electric Research Laboratory, Schenectady, N. Y., has been named by the National Junior Chamber of Commerce as one of America's ten outstanding young men of 1954. Dr. Hollomon was honored for his leadership in metallurgical research, and for special service to his country in war and peace. He received his bachelor and doctor of science degrees from the Massachusetts Institute of Technology. After a period of service on the faculty of Harvard University, he served in the U. S. Army from 1942 to 1946, attaining the rank of major. While in the Army, he was chief of physical metallurgy at the Watertown (Mass.) Arsenal. He was awarded "The Legion of Merit" for his work in the service.

Dr. Hollomon joined G.E. in 1946, and has served as advisor for metallurgical activities at the Knolls Atomic Power Laboratory, as well as assistant manager and manager of the metallurgy department. Since 1953 he has been a member of the High-Temperature Panel of the National Science Foundation. He has authored or co-authored some 40 papers, as well as a textbook on "Ferrous Metallurgical Design". Since *Acta Metallurgica* was established in 1952, he has served as secretary-treasurer, and holds the post

of adjunct professor at Rensselaer Polytechnic Institute and is a member of R.P.I.'s Development Council. He is a fellow of the American Physical Society, and a member of the American Institute of Mining and Metallurgical Engineers, British Institute of Metals and Iron and Steel Institute, American Association for the Advancement of Science, and the New York Academy of Science.

John W. Higgins has been appointed district sales manager of the St. Louis, Mo., territory of the Columbia Tool Steel Co. He has been with the company since March 1954 as a service technician. A native of the St. Louis area, Mr. Higgins has spent most of his adult life in various supervisory capacities in charge of heat treating and process research in that district.

John Q. Adams has retired from the metallurgical and chemical department of General Electric Co., Schenectady, N.Y., and has opened a consulting office in Whittier, Calif.

Robert K. Little, who graduated from Texas Western College in June '54 with a degree in metallurgy, is employed as a field engineer by the Youngstown Sheet and Tube Co., with his office in Midland, Tex.

William E. Weber, formerly employed by Continental Foundry and Machine Co., Wheeling, W. Va., is now a development metallurgist with the United States Steel Corp. in the Duquesne, Pa., works.

Thomas L. Altshuler was recently employed as a design and development engineer by the Radio Corp. of America in the semiconductor chemical physical laboratory in New York.

David Krashe is the newly elected vice-president of Canadian International Rich Metals Corp., Winston, Alberta.

A. E. Durkin, formerly at Thomson Laboratory, General Electric, is now operating his own company, American Metal Processing, in Wakefield, Mass. The new company specializes in anodizing and other chemical processing of aluminum, steel and magnesium.

Look into REVERE EXTRUDED SHAPES

—it may pay you as it did Westinghouse

When engineers of the Westinghouse Electric Corporation, East Pittsburgh, Pa., designed an inner-cooled generator rotor, the problem of making the hollow rotor coils arose. It was decided to make these out of two channel sections, butted together. Such channels could be made by milling solid copper bar, but Westinghouse knew how expensive such a process is. Could Revere produce the channels by the extrusion process? We thought we could, and after close collaboration with Westinghouse engineers, the various design and extrusion requirements were finalized. The channels are extruded, drawn, annealed, and then given a final draw.

Generators containing these special rotors are cooled by forcing hydrogen through the inner-cooled conductors at 30 psig. Because the heat is picked up directly from the copper, cooling performance is greatly increased over former designs. As a result, generator output can be approximately

doubled without increasing physical size. To put it in other ways, output is increased per pound of generator weight and per pound of fuel.

Extruded shapes can save a great deal of machining time and money, and make new ideas commercially practical. Come to Revere for them in copper and its alloys and aluminum alloys.

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Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.;
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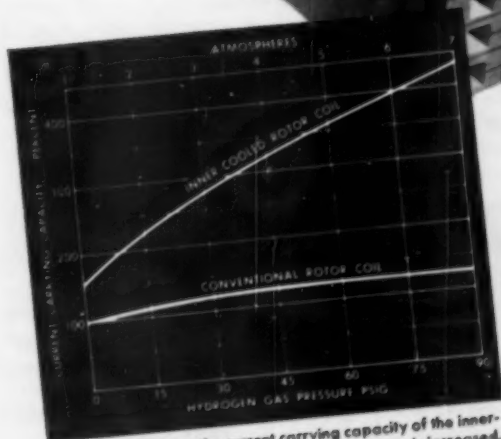
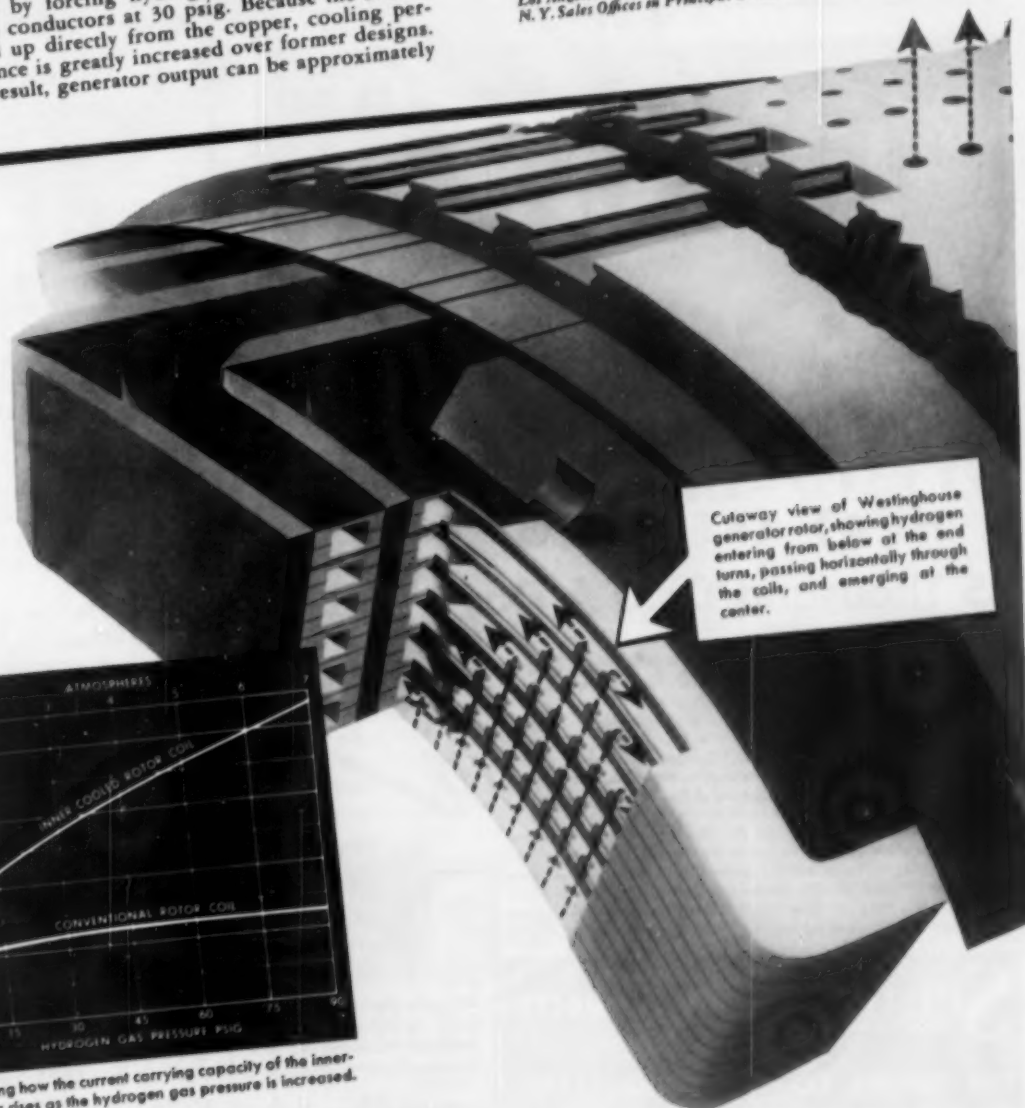


Chart showing how the current carrying capacity of the inner-cooled rotor rises as the hydrogen gas pressure is increased.

Personals . . .

Louis F. Fitzpatrick ☉, who has been a member of the staff of Shawinigan Chemicals Limited, Montreal, Que., for the past ten years, has been appointed sales manager of the company's stainless steel and alloys division. A native of Montreal, Mr. Fitzpatrick graduated from McGill University in chemical engineering in 1943 and went overseas with the Royal Canadian Engineers. On his discharge in 1945, he joined Shawinigan in the chemicals division at Shawinigan Falls, transferring to the stainless steel and alloys division two years later. He was made assistant sales manager of that division in 1953.

Wilson D. Trueblood, Jr., chairman of the Milwaukee Chapter ☉, and Milwaukee district sales manager for Leeds & Northrup Co., recently was awarded a 30th-anniversary plaque by his company. Mr. Trueblood graduated from the University of Wisconsin in 1922 with the degree of bachelor of science in chemical engineering. He joined Leeds & Northrup in 1924, and for many years has represented the firm in the upper Midwest.

Harold W. Hanes ☉ has been appointed research metallographer for the Vanadium Corp. of America at its new research center in Cambridge, Ohio. Mr. Hanes was formerly metallographer at the Ford Motor Co. plant in Cincinnati, Ohio.

Gordon McMillin ☉, formerly works manager with General Steel Castings Corp., Granite City, Ill., has joined Canadian Car and Foundry Co., Ltd., Montreal, Quebec, as assistant vice-president. He is in charge of foundry operations at the Longue Pointe plant.

Douglas P. Ferguson ☉, formerly chief metallurgist of the Wilson Foundry Div., Willys Motors, Inc., Pontiac, Mich., has been appointed "Ferrocarbo" engineer in the abrasive engineering department of the bonded products and grain division of the Carborundum Co., Niagara Falls, N.Y. Mr. Ferguson received the degree of bachelor of metallurgical engineering from Rensselaer Polytechnic Institute in 1947 and did advanced study in metallurgy at the University of Michigan. He was successively plant engineer and metallurgist for Neehan Foundry, Neehan, Wis., metallurgist with Dearborn Specialty Foundry of Ford Motor Co., and then chief metallurgist for Wilson Foundry Div. of Willys Motors, the position he held prior to his present appointment.

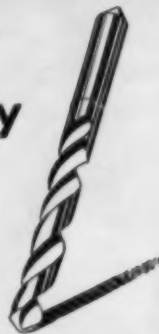
P. C. Clarke ☉ was elected director and appointed vice-president of the Eastern Metals Research Corp. of New York at its last annual meeting of stockholders. Mr. Clarke is executive vice-president and director of the Hunter Spring Co., Lansdale, Pa. Formerly an engineer with the Westinghouse Electric Corp. and later the General Electric Co., he has been associated with the Hunter Spring Co. since 1932.

William H. McCormick ☉ and **J. Herbert Whelan** ☉, two veteran employees of Crucible Steel Co. of America, have been promoted in the company's sales organization and will have their offices at the headquarters in Pittsburgh. Mr. McCormick, formerly chief metallurgist at Crucible's Park Works, Pittsburgh, has been appointed manager of sales of the alloy and carbon division. He will also be available as a consultant to other sales divisions within the company. Mr. Whelan, who has been assistant manager at Crucible's Chicago branch sales office and warehouse, has been appointed warehouse merchandising consultant. Both Mr. McCormick and Mr. Whelan came with the company in 1923.



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For real endurance and accuracy in heat treating high speed steels, the New Process Twist Drill Company of Taunton, Massachusetts recommends Sentry Furnaces without reservation. Daily heat treating of 9 to 15 thousand drills, miscellaneous milling cutters and form tools of M1 and M10 types of high speed steel with complete freedom from decarburization, calls for utmost furnace performance and reliability. Sentry High Speed Steel Hardening Furnaces with the Sentry Diamond Block Atmosphere assure highest quality hardening and elimination of costly spoilage. Here at New Process under exacting production requirements, Sentry equipment has again proved its worth.



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You get exceptional *uniformity*, too. For once a standard for *your* application has been set, hardness tests, and bend tests for toughness, insure *exact duplication of production lots*.

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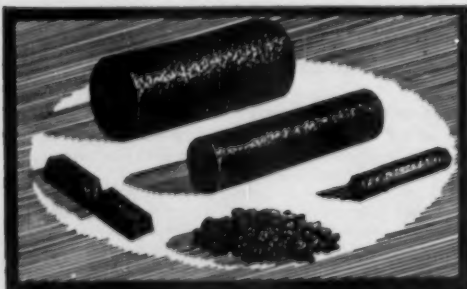
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CU-NI
ALLOYS
NI-CR
ALLOYS
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NI-CR-FE
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CR-FE
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Personals . . .

John Anglim ☉, chief metallurgist of the American Motors Corp., division of Nash-Kelvinator Corp., in Kenosha, Wis., has retired after 42 years with the company. Mr. Anglim joined the organization, then the Thomas B. Jeffery Co. of Kenosha, in 1912, and became chief metallurgist in 1918 when the Nash Motors Co. was organized. He started his technical career 50 years ago, in 1905, as an analyst for the Wisconsin Steel Co. in Chicago. Whitney Snyder ☉, assistant chief metallurgist at the American Motors Corp. Kenosha plant, has been promoted to chief metallurgist to fill Mr. Anglim's position.

Irwin Wittick ☉ has resigned as vice-president of W. L. Rives Co., Jacksonville, Fla., to take the position of awning division manager with the Chamberlain Corp., Waterloo, Iowa.

J. E. Massey ☉ has been appointed sales engineer for Delta Tank Mfg. Co., Inc., Baton Rouge, La. Mr. Massey, a graduate of the Agricultural and Mechanical College of Texas, previously was chief estimator for Wyatt Metal and Boiler Works in Houston, Tex.

Ernst M. Goldstein ☉ is now research chemist at Nickel Processing Corp., Elizabeth, N.J.

Joseph M. Denney ☉, formerly a research engineering consultant with North American Aviation Co., has been appointed a research associate in the metallurgy department, General Electric Research Laboratory, Schenectady, N.Y. Dr. Denney is a graduate of California Institute of Technology, where he received his M.S. and Ph.D. degrees.

F. L. LaQue ☉, vice-president and manager of the development and research division of International Nickel Co., has been appointed to the national panel of arbitrators of the American Arbitration Association. Mr. LaQue received his degree in chemical and metallurgical engineering from Queen's University in Canada in 1927, and has been active in this field ever since. As a member of the national panel, he will be available for selection by parties submitting disputes to arbitration.

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Treat your steel forging dies with 'dag' Colloidal Graphite and increase the number of acceptable forgings per die by as much as 100 percent. The *dry lubricating film* formed by colloidal graphite protects both dies and forgings. Freedom from scaling and sticking often eliminates some of the usual finishing operations on forgings, and greatly extends die life.

'dag' Colloidal Graphite is much more effective than ordinary high-temperature lubricants, including the best of powdered graphite. It is high-purity, electric-furnace graphite, specially treated by Acheson to produce microscopically fine particles. Dispersed in many fluid carriers for convenient application, 'dag' Colloidal Graphite will not burn, flake, or gum, at temperatures commonly encountered in metalworking operations.

'dag' dispersions are used profitably in stamping, deep-drawing, piercing, casting, forging, stretch-forming, and wire drawing. You'll find a surprising number of ways to use 'dag' dispersions described in our free booklet on 'dag' Colloidal Graphite for Metalworking Operations. Write for Bulletin No. 426-X1.

Dispersions of molybdenum disulfide are available in various carriers. We are also equipped to do custom dispersing of solids in a wide variety of carriers.

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**WIDE
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UP TO 2" x 12"

Wyckoff Precision Wide Flat Sections are cold drawn to close tolerances and will definitely reduce your machining and assembly costs for gauges, gigs and fixtures, machine tool bases, die plates, and other heavy machinery parts.

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**WYCKOFF STEEL PRODUCTS—Carbon and Alloy Steels • Turned and Polished Shafting
Turned and Ground Shafting • Wide Flats up to 12" x 9" • All types of furnace treated Steels**

Personals . . .

C. D. D'Amico ☼ has been named manager of sales at the Los Angeles plant of Joseph T. Ryerson & Son, Inc. Filling the post of manager of the stainless steel department vacated by Dr. D'Amico, is F. X. Kinzie ☼ who formerly was a sales representative for the department. Dr. D'Amico became associated with the Los Angeles plant in 1947 as manager of the special steel department. Previously he had been engaged as a metallurgical engineer on the West Coast, following his graduation from the University of Michigan in 1939, where he obtained the degrees of M.S. and Ph.D. in metallurgy. Mr. Kinzie attended Purdue University, joining the company at Chicago in 1937. He was a sales representative for the plastic bearings and babbitt metal division before his transfer to Los Angeles in 1946 to assume similar duties. He left this position in 1951 to become a sales representative for the stainless steel department.

Edward J. Planz ☼, formerly research and development metallurgist with Kaiser Metal Products, Bristol, Pa., has accepted a position as development metallurgist at Wallace Aviation Corp., Wallingford, Conn.

Edward W. Sparkes ☼ has been appointed acting manager of the Syracuse, N.Y., area sales branch of Crucible Steel Co. of America. Mr. Sparkes joined Crucible in 1935, and was employed in various capacities until securing a leave of absence in 1942 to enlist in the U.S. Army. Upon discharge from the military in 1946, he returned to Crucible at Syracuse to become a member of the company's sales force there. He was appointed sales service engineer early in 1947, the position he held until his recent promotion.

Thomas O. K. McClure ☼ recently retired as gear specialist at the Allison Div. of General Motors Corp. in Indianapolis, Ind., with 23 years' service behind him. With all of his working years spent on gears, Mr. McClure has served with Pittsburgh Model Engineering, with Ford Motor Co., 10 years with Studebaker Corp., and then his first General Motors connection—with Pontiac Motors, Pontiac, Mich.

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WATER QUENCH removes much of the loose scale. The steam generated by immersing the hot metal in the water further loosens scale by its blasting action. The work is thus prepared for the final acid dip.



THREE-MINUTE DIP in dilute acid removes the now soluble scale. The work is ready for a rinse or hosing to wash off the acid. Result: a chemically clean surface—no pitting, etching or metal loss. TOTAL TIME—15 MINUTES.

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—Get the whole story on Virgo Descaling Salt and Virgo Molten Cleaner—what they are, how they work, their advantages, how they fit your operations, and the Hooker services you enjoy as a user of the process. Send for these bulletins today.



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VIRGO DESCALING SALT—Producers and fabricators of stainless and alloy steels use Virgo Descaling Salt to quickly, positively remove scale produced by hot rolling, forging, extruding, casting, annealing.

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This process can be used on steel; castings; forgings; fabricated parts; material to be salvaged. It employs simple equipment, and is easily adapted to your production methods.

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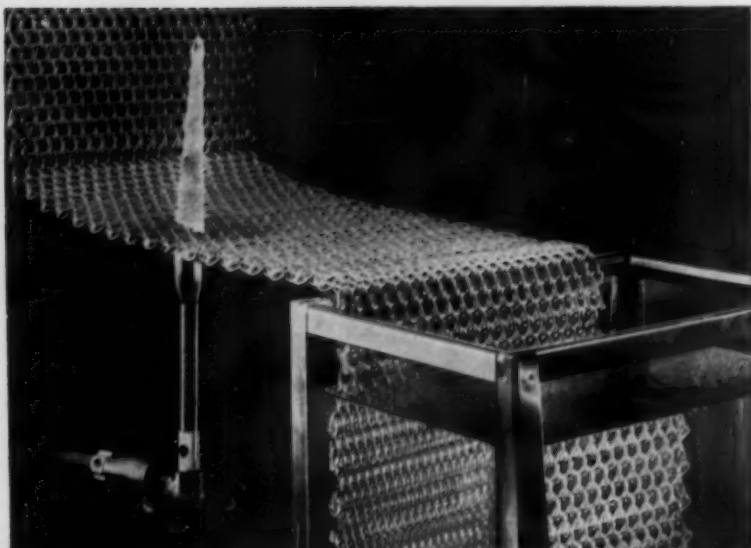
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All-metal belt . . . corrosion resistant and impervious to damage at temperatures up to 2100° F . . . withstands most severe conditions of annealing, tempering, brazing, as well as quenching, pickling, washing. Moving belt eliminates batch handling, cuts costs, provides continuous production.

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METAL PROGRESS; PAGE 132

Personals . . .

H. T. Coghill has joined the sales staff of the refractories division of the Carborundum Co. and is now working in the Cincinnati territory. Mr. Coghill attended Antioch College and the University of Michigan, majoring in mechanical and chemical engineering. After graduation he joined the technical staff of the American Cyanamid Co., where he stayed for 12 years. He then went to Ampco Metals as manager of the Chicago district. After six years there he formed his own company, operating as a manufacturers' agent, serving the metallurgical and process industries.

James M. Robinson has been appointed assistant branch manager of the Springfield, Mass., sales branch of Crucible Steel Co. of America. Mr. Robinson began his career with Crucible upon graduating from the University of New Hampshire in 1936 with a bachelor of science degree in chemical engineering. His first assignment with the company was in Pittsburgh, and since 1939 he has been associated with the Springfield branch.

Hjalmar A. Anderson, formerly assistant chief engineer of the industrial furnace division of Sunbeam Corp., was recently appointed chief project engineer of Lindberg Industrial Corp., Chicago.

Felix Kremp has been appointed assistant manager of the toolsteel sales division of Crucible Steel Co. of America, and will be primarily responsible for the sales of the division's products produced at the company's Park Works, Pittsburgh. Upon graduation from Cornell University in 1915, Mr. Kremp joined Crucible's metallurgical department at Park Works. In 1919, he left the company to accept a position as metallurgist with Atlas Steel Co., Dunkirk, N.Y., and six years later became associated with Braeburn Steel Co., Braeburn, Pa., as assistant sales manager. Rejoining Crucible in 1934, Mr. Kemp has since served in the company's general sales department. From 1951 through 1953, he was on loan to the National Production Authority in Washington, D.C., as chief of the toolsteel section.

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The difference results from the inherent soundness of the metal itself...and its uniformity of chemical composition, physical properties and dimensions...from lot to lot and order to order.

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Over the past few years, Mallory-Sharon and the few other titanium producers have approximately doubled output every year. Technical developments—that took years with other metals—have been accomplished in months with Titanium.

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MALLORY  SHARON

METAL PROGRESS; PAGE 134

Personals . . .

Harold J. Holmes ♂, formerly chief engineer of Atlas Press Co., Kalamazoo, Mich., has been appointed assistant to the vice-president, engineering, at the Heald Machine Co., Worcester, Mass.

H. E. Sigwell ♂, formerly a sales engineer with the Detrex Corp., Detroit, is now general superintendent at the Steel Cabinet Mfg. Co., Philadelphia.

Maurice B. Kasen ♂, formerly in the physical metallurgy department at Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., is now employed by the Kaiser Aluminum and Chemical Co., Spokane, Wash.

Cameron Clyde Mathias ♂ and **Leon Hurwitz** ♂ have organized the Metallurgical Specialties Co., Inc., Lancaster, Pa.

William Durako ♂, who graduated from Drexel Institute of Technology in June 1954, has accepted a position as sales engineer with Crucible Steel Co. of America and is located in Syracuse, N.Y.

Richard L. Werner ♂ was discharged from the U.S. Army in November 1954 and is now employed by the R. D. Werner Co., Inc., Greenville, Pa., as assistant chief engineer.

George A. Barker, Jr. ♂ was recently elected president of Utility Products Corp., Miami, Fla. Mr. Barker is also president of Agog Engineering Corp. in the same city.

W. William Nash ♂, until recently metallurgist at Sikorsky Aircraft Div., United Aircraft Corp., in Bridgeport, Conn., is now metallurgist at Piasecki Helicopter Corp., Morton, Pa.

Roman Osadchuk ♂, who received his Ph.D. in metallurgical engineering from the University of Cincinnati in August 1954, is now with the Aluminium Laboratories Limited, Kingston, Ont.

Win St. John ♂ has resigned as production engineer for Technicraft Laboratories, Inc., Thomaston, Conn., and is doing consulting (engineering) as an independent, specializing in aluminum flux dip brazing and silicone rubber problems.



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Personals . . .

Harold Helgerson ☉, for six years chief metallurgist with the Chicago, Milwaukee, St. Paul and Pacific R. R. in Milwaukee, Wis., is now metallurgist for Rockwell Valves, Inc., Sulphur Springs, Tex.

William T. Warner ☉, formerly group leader in Reactor Operations Div., Brookhaven National Laboratory, is now staff metallurgist for the Atomic Energy Commission office at the Feed Materials Production Center, near Cincinnati, Ohio.

Lawson I. Ainsworth ☉ has been transferred from the toolsteel sales division of Bethlehem Steel Co., Bethlehem, Pa., to the New York district sales office in New York City.

K. L. Jansen ☉, who was formerly associated with the coated abrasives division of Armour & Co. in Alliance, Ohio, as quality control manager and abrasives sales engineer, has been appointed assistant sales manager for the centrifugal casting division of Shenango-Penn Mold Co., Dover, Ohio.

Walter Kilimnik ☉, who was carbon production manager on the general staff of U.S. Steel Supply Co., Chicago, is now sales manager of Solar Steel Corp., Los Angeles.

Joseph Robert Schettig ☉, who was graduated from Pennsylvania State University last August with a master's degree in metallurgy, is now employed as a research assistant at Armo Research Laboratories in Middletown, Ohio.

Seymour Goodman ☉, former instructor in metallurgical engineering at the Polytechnic Institute of Brooklyn, is now materials engineer at the David Taylor Model Basin, a U.S. Navy research and development installation in Washington, D.C.

Edward L. Badwick ☉ was recently transferred from the Eclipse-Pioneer Div. of Bendix Aviation Corp. at Teterboro, N.J., to the Red Bank Div. of the Corporation, where his duties as a metallurgical engineer will be similar.

Donald E. Vreeland ☉ is now employed in the research and development laboratory of United States Steel Corp., Pittsburgh.

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Personals . . .

James K. Goldsmith is now assistant superintendent, sponge production, for Cramet, Inc., a wholly-owned subsidiary of Crane Co., in Chattanooga, Tenn.

William J. Mulvehill was recently made central Ohio manager for the Dale Carnegie Institute. Formerly chief metallurgist for Motch & Merryweather Machinery Co., Cleveland, Mr. Motch resigned this position in early 1953 to become area manager for his present firm, the office he held until his promotion.

R. Doughton, Jr. has resigned from the materials advisory board of the National Academy of Sciences to become development engineer in product development division, Jones & Laughlin Steel Corp., Pittsburgh.

Joseph C. Fox, long associated with the Doehler-Jarvis Corp., Toledo, Ohio, as chief metallurgist, has opened an office in Toledo for consultation on matters pertaining to the chemical and metallurgical phases of the die casting process.

Cecil F. Baxter, until recently metallurgist with Ford Motor Co. of Canada, East Windsor, Ont., has accepted a position in the research and development section, Canadian National Railways, Montreal.

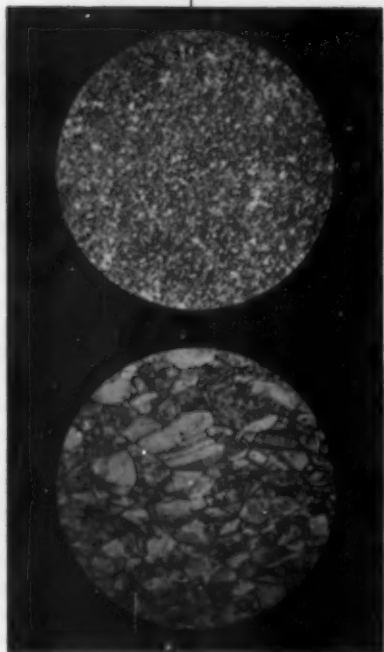
A. R. Gaus has been elected a vice-president of Erie Forge & Steel Corp., Erie, Pa. Before joining the Erie Forge organization, Mr. Gaus was vice-president of the Midvale Co., Nicetown, Philadelphia.

Fred C. T. Daniels recently retired as vice-president of research and development for Mackintosh-Hemphill Co., Pittsburgh—the position he has held for the past 26 years. A native of Vermont, he received a degree in chemistry from Worcester Polytechnic Institute in 1904, and has been an active participant in the metallurgical development of the iron and steel industry throughout the past 50 years. He holds 18 patents, mostly pertaining to cast iron and cast steel rolls. Continuing to serve in a consulting and advisory capacity to Mackintosh-Hemphill Co., Mr. Daniels will reside at Waretown, N.J., in order to be close to his favorite fishing and cruising on Barnegat Bay.

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a NEW fine-grain phosphor bronze with 30% GREATER ENDURANCE LIMIT

FINE-GRAIN STRUCTURE IS THE MAIN REASON . . .



Micrographs (75x magnification) tell the inside story. Top, note the fine-grain structure of DURAFLEX. Compare it with the grain structure of ordinary phosphor bronze, bottom.

Try a **FREE SAMPLE** of

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Sheet . . . up to 0.062" thick
Wire . . . up to $\frac{3}{16}$ " diameter (approx.)

DURAFLEX* is a new, fine-grain phosphor bronze developed and sold only by Anaconda. Comparative fatigue tests show that the endurance limit of DURAFLEX is approximately 30% higher than for ordinary phosphor bronzes. In surface appearance, surface smoothness and resistance to corrosion, it is equal to, or better than, other phosphor bronzes. Further, its formability is increased with no sacrifice in yield strength. DURAFLEX is a *premium* phosphor bronze in every way except cost; there's *no increase in price*.

If you're now using a hard-temper phosphor bronze, chances are that you can do the same forming in extra-hard temper DURAFLEX. If you're looking for longer life in the parts you form, we'll be glad to send you a free sample of DURAFLEX. Try it, test it, and you will agree that it's superior.

6076

Trade-Mark

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an **ANACONDA**[®] product
MADE BY THE AMERICAN BRASS COMPANY

FREE SAMPLE

The American Brass Company, Waterbury 20, Connecticut
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Yes, we'd like to try DURAFLEX. Please send us a free sample of
sheet in _____ temper, _____ thick,
wire in _____ temper, _____ diameter.
☐ We'd like to talk to one of your metallurgists about DURAFLEX.

NAME

COMPANY

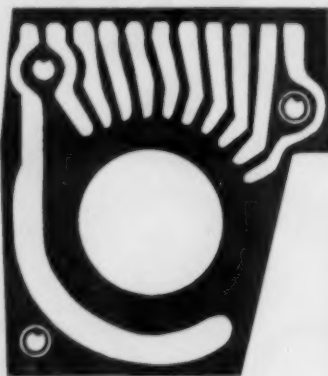
STREET

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What's going on in NON-FERROUS METALS

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is more precisely compounded and free of flaws. Used increasingly for printed circuits (as pictured at right) in the electronics field, for sheet metal work, and for general soldering everywhere in industry. Called CASTOMATIC® solder, it is made on patented machines, by Federated only. Write for 36-page "Solder" brochure.

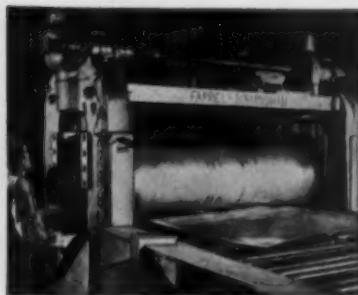


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is an effective chemical reducing agent; yields salable by-products; costs less than other reducing agents. It is also used in paints which protect against corrosion.

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is used in the new Deep Therapy room of Seattle's Swedish Hospital. Federated supplied metallurgical help and all the lead. Through Federated, American industry has access to the acknowledged center of lead research and technical service. Ask for 48-page "Lead Handbook".



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Characteristics of Creep*

THE PAPER is essentially a condensation of a number of articles written by W. A. Wood and his co-workers. It describes how the crystal structure of metals, such as aluminum, changes during high-temperature deformation. Contrary to the results for short-time tensile tests at room temperature, no strain hardening and no distortion of the grains occurs in steady-state creep. As the temperature is raised, fewer and fewer slip lines are observed until flow without observable slip takes place. Probably the most characteristic structural feature of creep is the formation of sub-boundaries. It is observed that small subgrains form soon after the load is applied. They grow during primary creep until they reach an equilibrium size at the end of the primary stage of creep. During secondary creep, the creep strain rate and the size of the subgrains remain essentially constant. When the specimen finally fractures during tertiary creep, it is observed that the over-all substructure has not changed. The specimen merely breaks on account of the weakening of a local region.

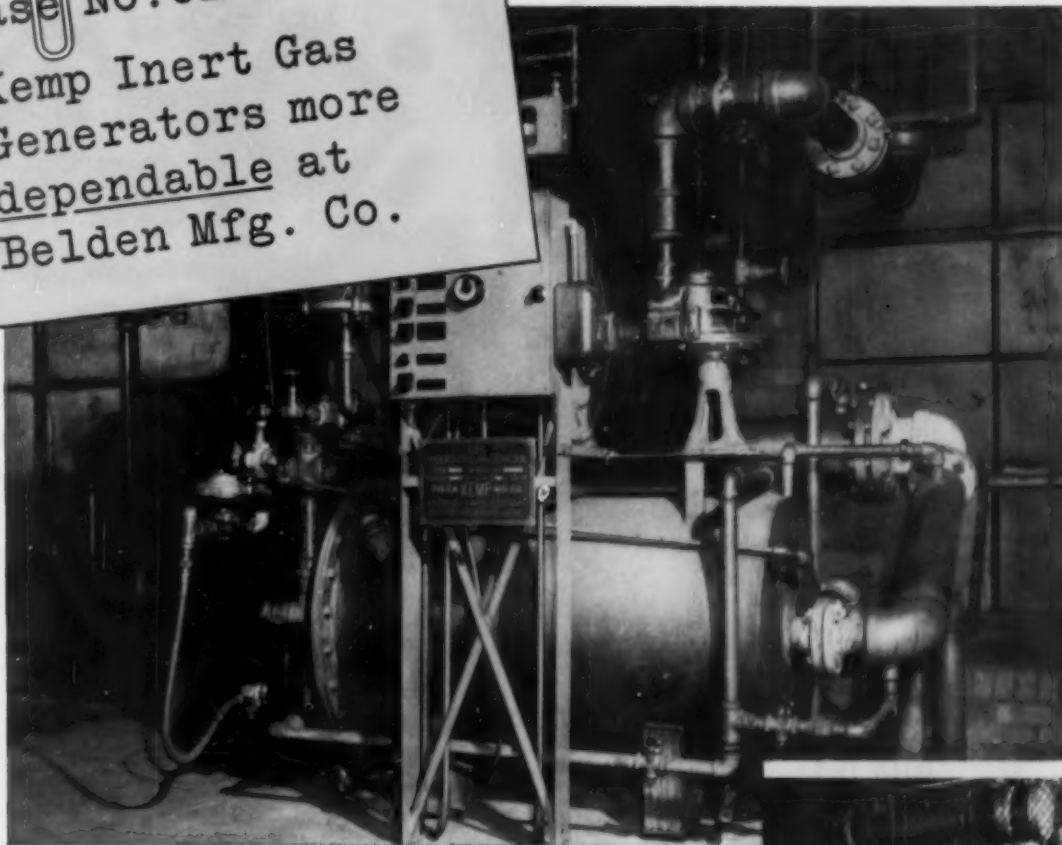
The subgrain size is best indicated by X-ray diffraction measurements. A reflection spot of an annealed grain breaks down into a number of smaller spots during primary creep, indicating that subgrains have formed within the initial grain. Both the size of these subgrains and their orientation relationships are deduced from the X-ray pattern. Subgrain sizes may be measured also from micrographs of the deformed material. The X-ray method, as well as the optical method, shows that the subgrains may be as small as 10^{-4} cm.

The conditions under which sub-boundaries form during creep are considerably different from those under which they form during recovery in ordinary annealing. Sub-boundaries can form during creep at temperatures that are too low for them to form in ordinary recovery. For example, in aluminum of 99.8% purity (Continued on p. 142)

*Digest of "Creep Processes", by W. A. Wood, Symposium on Creep and Fracture of Metals at High Temperatures, May 31, June 1 and 2, 1954, National Physical Laboratory, Teddington, England.

Case No. 61

Kemp Inert Gas
Generators more
dependable at
Belden Mfg. Co.



How Belden utilizes two Kemp Generators in annealing copper wire

Annealing copper wire necessitates cooling in an oxygen-free atmosphere to prevent harmful oxidation. For the required protective atmosphere in this process, the Belden Mfg. Co., Chicago, Ill., generates its own inert gas. But the generating equipment formerly used by Belden did not operate reliably . . . results were erratic. So Belden installed two Model MIHE Kemp Inert Gas Generators to handle this important job.

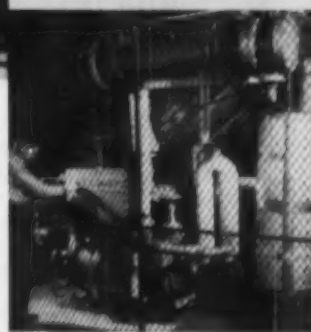
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These two Kemp units assure Belden of a *dependable* inert supply. They deliver a more constant flow at the rated pressure . . . have been operating smoothly and

satisfactorily since installation. Kemp's ability to produce a chemically clean inert at a *specific analysis regardless of demand* eliminates the danger of fluctuation at a critical stage.

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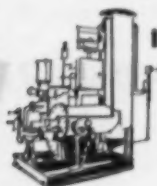
Like Belden, you specify reliability when you specify Kemp. Every Kemp design includes the Kemp Industrial Carburetor for complete combustion without tinkering, without waste . . . for simplified installation and maintenance. Every Kemp design includes the very latest fire checks and safety devices. Annealing, hardening, sintering—whatever your problem, find out today how Kemp engineers can help you.



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For more complete facts and technical information, write for Bulletin I-10 to: THE C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.

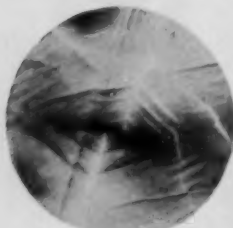
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Interesting Metal Structures Come to Light



(Top) Aluminum grain structure, showing spiral dislocation. Parlodion replica. Chrome shadowed.



Mr. Robert Mapes, Metallographer at Reynolds Metals Co., Richmond, Va., operating the new RCA EMU-3A Electron Microscope, with Dr. John T. McCormack, Metallurgical Consultant, looking on.

(Right) Aluminum grain showing sub-grain structure. Parlodion replica. Chrome shadowed.



... with the RCA ELECTRON MICROSCOPE

In fundamental research with the electron microscope, Reynolds Metals Company examines metal structures by surface replica techniques and contrasts enhanced by "shadowing" with a thin film of chromium. Structures too small to be seen with the light microscope are clarified and features revealed by electron micrographs. Such studies are leading to improved performance and fabrication characteristics in the metals.

The electron microscope also is used on ferrous metals for quantitative measurement of grain size, undissolved carbides, retained austenite and other secondary phases.

Ideal for basic research and development work, the new EMU-3A and EML-1A Electron Microscopes provide magnification and resolution higher than ever before possible and include many advanced engineering features. We invite you to find out more about this revolutionary new RCA equipment as a solution to your research problems. Installation supervision is supplied and contract service by the RCA Service Company is available if desired.

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**RADIO CORPORATION
of AMERICA**

Creep Characteristics . . .

ity and of 0.1 mm. grain size they form between 300 and 355° F. At these temperatures they can migrate large distances that cannot be achieved at the highest temperatures usable in ordinary recovery.

The equilibrium subgrain size that is reached at the end of the primary stage of creep depends mainly on temperature and strain rate in a certain material. It increases as the temperature is raised or the strain rate lowered. The mechanical strength is closely related to the sub-grain size; it is found to decrease with decreasing size of the cells. Evidently, the resistance to deformation is due to the sub-boundaries and not to possible barriers inside the cells. As the cell size reaches its equilibrium value at the end of the primary stage of creep, the resistance to deformation also reaches a constant value.

Another important aspect of creep is the relation between creep strain and structure. Strangely enough, it is often observed that the over-all grain size and grain shape do not change even if the total elongation of the specimen is 100%. This is contrary to the standard deformation at room temperature where the total elongation of the specimen generally equals the average grain elongation. As the temperature is raised, the standard process of grain extension becomes inactive while grain-boundary flow sets in. It is observed that regions at the grain boundary may strain 100%, due to grain boundary flow, while the interior of the grain remains unstrained.

The structural changes that occur during creep may vary considerably for different materials. Aluminum and tin represent one extreme where deformation at high temperature produces structural changes quite different from those caused by the standard deformation at room temperature. In other metals, like lead, copper, alpha-brass and zinc, the difference is less pronounced.

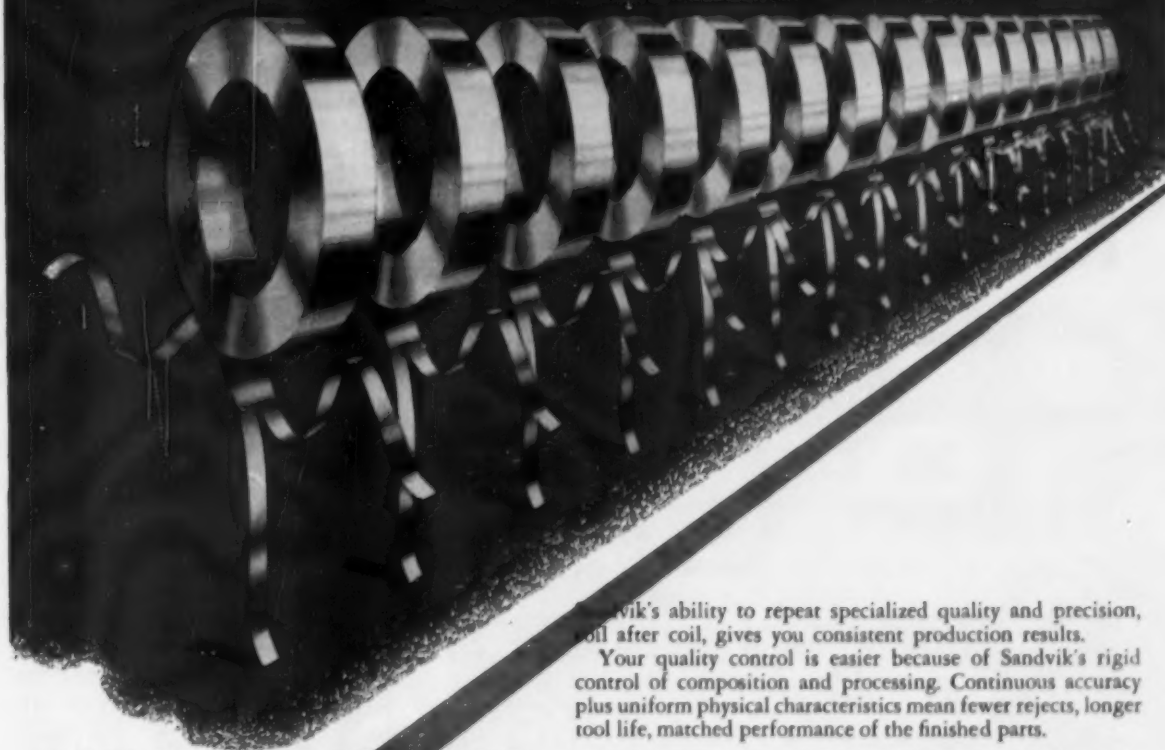
Reviewer's Comment

The main merit of the paper lies in describing creep phenomena rather than explaining them. To interpret his observations, the author introduces or uses a number of concepts that are somewhat hypothetical.
(Continued on p. 144)

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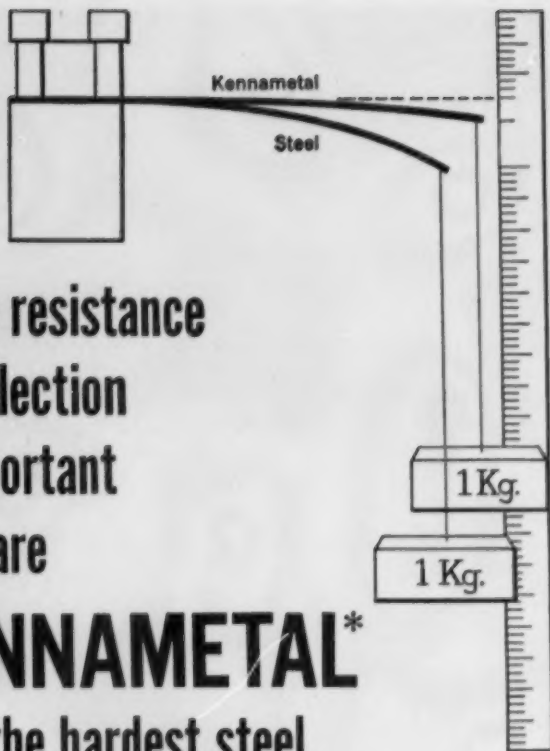
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*Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.



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Creep Characteristics . . .

ical. For example, he uses the term "slip-less flow" and proposes a mechanism whereby deformation in aluminum at higher temperatures takes place without slip. However, there are other possible explanations for the apparent disappearance of the slip lines at higher temperatures. One of them is that the spacing of the glide lamellae becomes too small to be resolvable with the light microscope. One investigator has demonstrated with electron micrographs that the spacings of the glide lamellae do indeed become smaller with increasing temperature although the spacings between slip bands, which appear as slip lines under a light microscope, become larger.

Another explanation of the disappearance of slip lines at higher temperatures is that the formation of an oxide film on the surface of the specimen prevents dislocation loops or slip from penetrating to the surface. C. S. Barrett (*Acta Metallurgica*, Vol. 1, No. 2, 1953) has shown that dislocation loops will break to the surface when the oxide film is being removed by etching. The author then introduces the terms "single" and "multiple" slip by which he does not mean what is ordinarily understood under these terms, namely, glide by a single or by several slip systems. He uses these terms to describe the amount of glide on a single slip plane and implies that the amount of slip on a single glide plane suddenly becomes very small at high temperatures. It is difficult to accept this view since, on the basis of dislocation theory and from experimental evidence, the amount of slip on a single slip plane should slightly increase and not rapidly decrease with temperature.

The author's explanation of the formation of subgrains seems open to criticism too. It is not likely that individual grains will "break down" spontaneously as the author suggests. Dislocations that are already in the material or that are being generated by the deformation will rather diffuse together to form small-angle boundaries; and these small-angle boundaries will then grow in order to lower the free energy of the grain. Currently, this seems to be the gen-

(Continued on p. 146)



ROTOBLAST TABLE-ROOM. Vapor Heating Corp., Chicago, saves 10 man-hours per unit with Pangborn Rotoblast Table-Room.

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There are two simple reasons why Pangborn Rotoblast gives you faster and cheaper blast cleaning. Rotoblast is *faster* because it throws a heavy volume of abrasive over a large area at great speed. You get a thorough cleaning job quickly. It is *cheaper* because, in addition to cutting working time, it saves labor costs and requires less power to operate. Whatever you clean and whatever blast cleaning machine best suits your needs—table, barrel, room, table-room, cabinet—Pangborn Rotoblast can save you money! Investigate Pangborn Rotoblast now. Write for Bulletin 214 to: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md.

*U. S. Pat. 92184926 (other patents pending)



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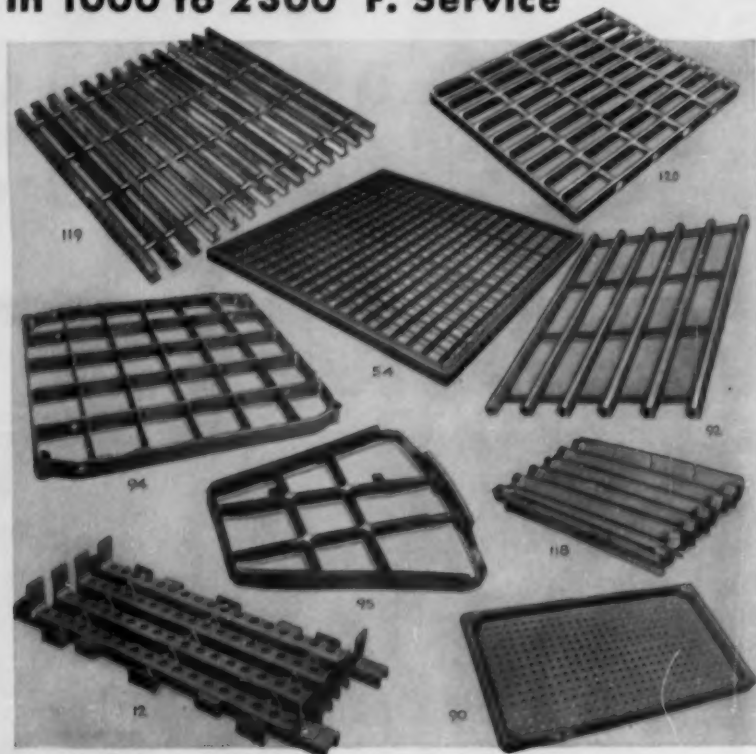


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Creep Characteristics . . .

erally accepted view. Finally, it should be said that further work is needed to explain why grain size and grain shape do not change in creep even if the deformation of the specimen is as large as 100%. This phenomenon may be due to continuous recrystallization rather than to the mechanism proposed by the author.

A. W. COCHARDT

Properties Needed in Creep Resisting Alloys*

PROPERTIES required in creep resisting alloys are described, as are the basic principles that have to be considered for their development and application. The paper deals especially with the essential part played in the resistance to creep by fine precipitates of additional phases, and the importance of heat treatment by which the nature, size and distribution of these precipitates can be controlled.


The authors recognize the need for easy fabrication and shaping into a final form, and consider the castability, forgeability and weldability of alloys as these are related to commercial application.

Creep resistant alloys must also have satisfactory resistance to corrosion, fatigue and thermal shock. The order of importance of these properties will depend upon the particular application. In some instances the corrosion problem may be solved by suitable surface coatings.

Creep resistance is defined as the resistance to deformation under the action of a load at constant temperature. In practice the material at elevated temperatures should not strain more than a certain value, generally less than 1%, during the expected life, and rupture should not occur. Creep resistant materials are nearly always alloys. For these, the fundamental criterion of resistance to creep is evidently chemical composition. Alloying elements may act in different ways:

(Continued on p. 148)

*Digest of "Basic Principles of a Creep Resisting Alloy", by A. Constant and G. Delbart. Symposium on Creep and Fracture of Metals at High Temperatures, May 31, June 1 and 2, 1954, National Physical Laboratory, England.



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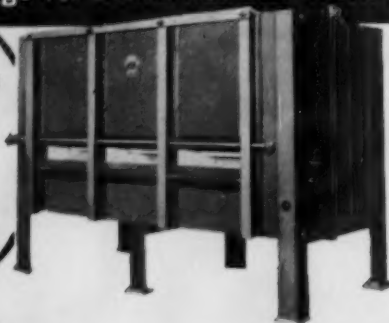
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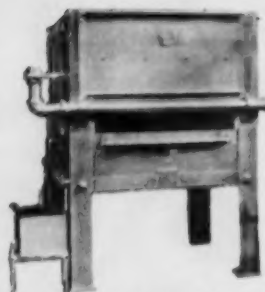
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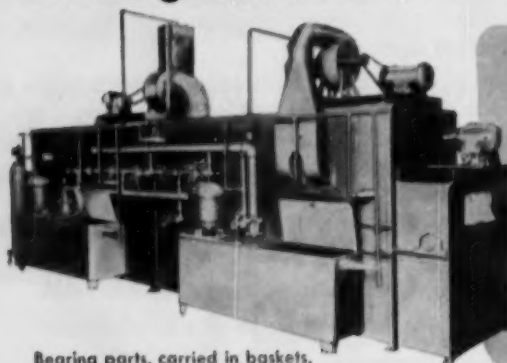
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Creep Resisting Alloys

1. By raising the temperature of recrystallization of the base material the most effective element being that which raises it the most.

2. By the presence of foreign atoms in solid solution in the lattice.

3. By the formation of precipitates of additional phases: carbides, nitrides, or intermetallic compounds.

This last factor is the most important. Precipitates impede the movement of dislocations. Their effectiveness is a function of their size, of their position in the lattice and of their stability.

The instability of a structure manifests itself in different ways during the progress of creep:

1. By recrystallization of the matrix; this is always a disadvantage.

2. By the coalescence of the precipitates, leading to a decrease in creep resistance.

3. By the resolution of a precipitate, resulting in a decrease in resistance.

4. By the disappearance of the phase with the appearance of a second phase which may be of great advantage if the second phase is more finely distributed and less prone to coalescence than the first.

5. By the appearance of a phase due to a process analogous to age hardening where an element present in excess in the lattice precipitates.

These last two processes may be extremely favorable to creep, since the precipitates can be formed in the very neighborhood of the dislocations, which can be displaced and thus oppose creep. These have been applied to austenitic alloys, but their usefulness in ferritic steels did not seem to be fully appreciated. With the ferritic alloys, the precipitates present before creep have to be taken into account as well as those that may form during the process of creep.

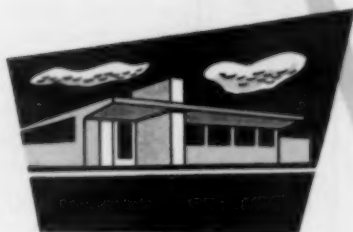
It is necessary that the precipitation occur in the grains themselves and not in the grain boundaries where it will cause embrittlement. A slightly unstable structure, in which finely dispersed precipitates resistant to coalescence are slowly formed, will give excellent creep properties.

Heat treatment has a vital effect on creep resistance on account of
(Continued on p. 150)

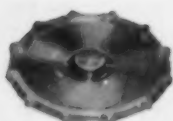
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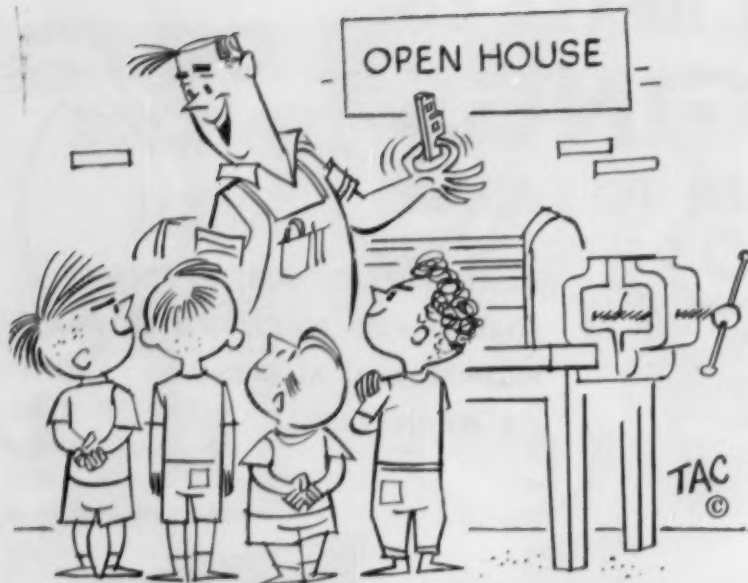
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MARCH 1955; PAGE 149



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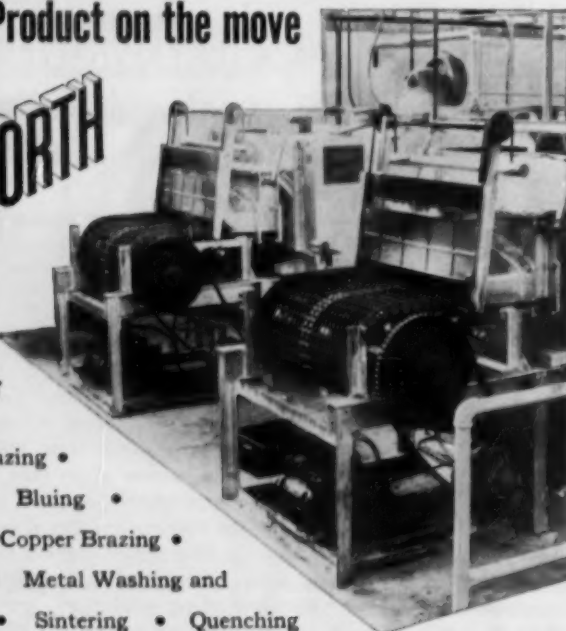


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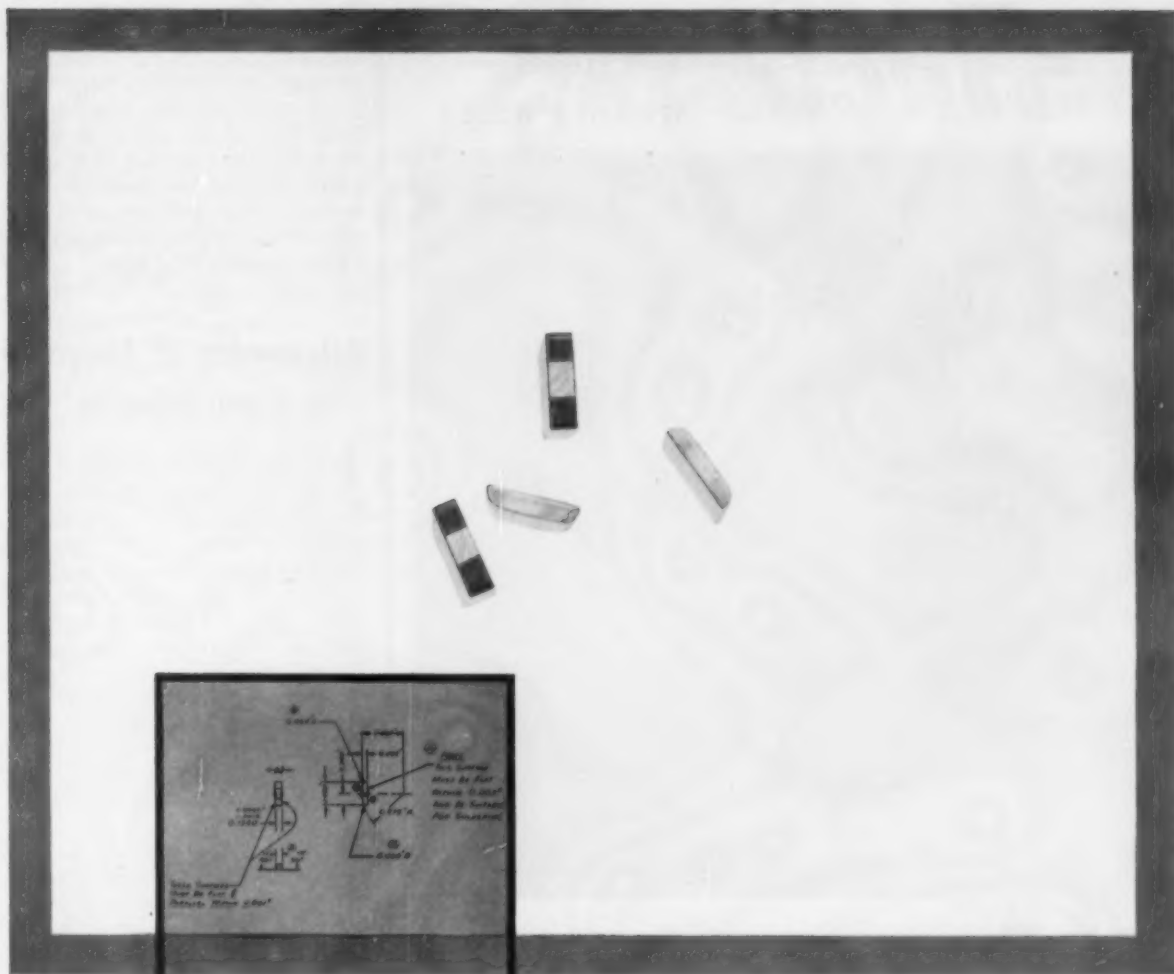
its influence on the form and nature of these precipitates, as well as on the possibility of their formation during the process of creep. The purpose of the heat treatment is to modify the chemical composition and distribution of the phases present. Variation of solubility of the additional phases, the difference in solubility of one phase in the other, and the possibility of obtaining different structures can all be affected by heat treatment.

For a 0.6% Cr, 0.6% Mo steel, bainitic or martensitic structures (which are more resistant at low temperature and high stresses than pearlitic structures) lose their superiority at high temperatures. The tensile strength of ten specimens that had received various treatments revealed hard structures to be less resistant to creep than soft structures at low stresses, but the opposite is true at higher stresses. Therefore, knowledge of the TTT-curve can be of great use when determining the desired heat treatment for the various uses of the material, and transformation in the bainitic or pearlitic ranges can be accomplished as desired.

For steels containing vanadium, the direct formation of vanadium carbide by transformation within the pearlitic range produces secondary hardening from a martensitic or bainitic structure. The precipitation is accompanied by expansion and is readily shown in dilatometer tests. Dilatometer curves show inflections, present from transformation and secondary hardening, which disappear with various heat treatments.

Suitable choice of time and temperature provides a simple method of controlling the size (and creep resisting characteristics) of vanadium carbides. Incomplete tempering will produce a partial precipitation that will continue during creep and is useful for short-term applications. For long-term applications it is imperative to cool slowly so as to produce good cold properties and a structure amenable to secondary hardening.

It is important to remember that the most useful elements for their creep resisting properties are those that form carbides at highest temperature.
(Continued on p. 152)



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MARCH 1955; PAGE 151

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METAL PROGRESS; PAGE 152

Creep Resisting Alloys

peratures by secondary hardening. When another alloying element combines with all the carbon present, preventing the formation of the required carbides, the element to be used for creep resistance must be replaced by another element having a greater affinity for carbon.

E. S. RIDER

Relationship of Alloying to Creep Behavior*

THIS comprehensive and critical review of the recent literature on the subject opens with a short introductory discussion of the theories that have been proposed to explain the "transient and steady states of creep", or the first and second stages according to American terminology. The first stage is described as starting from thermal fluctuations at the weakest points of a specimen or structure, where the capacity for deformation shortly becomes exhausted. This exhaustion theory has been modified to include the conceptions of "replenishment" (with elements of different activation stress during flow) and strain hardening, accounting for the second stage of creep. The resulting ideas lead to the conclusion that the effect of alloying on creep should be predictable in view of the known effects of solute atoms on strain hardening and thermal recovery.

In the discussion of solid solution alloys, numerous publications are reviewed to indicate what is known regarding the effects of lattice distortion, as a result of alloying, on hardness and other mechanical properties. Strain hardening is increased in a wide variety of solvent metals. Several investigators have shown that the average number of electrons per atom, as well as lattice strain, account for hardening. The temperature causing loss of strain hardening is generally raised by small alloy additions, but as the alloying is increased a maximum effect is passed

*Digest of "The Effect of Alloying on the Creep of Metals", by L. A. Rotherham and L. G. Tottle, Symposium on Creep and Fracture of Metals at High Temperatures, May 31, June 1 and 2, 1954, National Physical Laboratory, Teddington, England.

because the alloy lowers the melting point.

Diffusion is an important factor and high diffusion rates increase creep. Strain hardening of the grains by alloying may cause stress concentration at boundaries and intergranular rupture. Unfavorable atom-size of the solute metal, or a large difference in melting points between solute and solvent metal, may complicate the effect of the alloy on creep by peculiar grain-boundary relations.

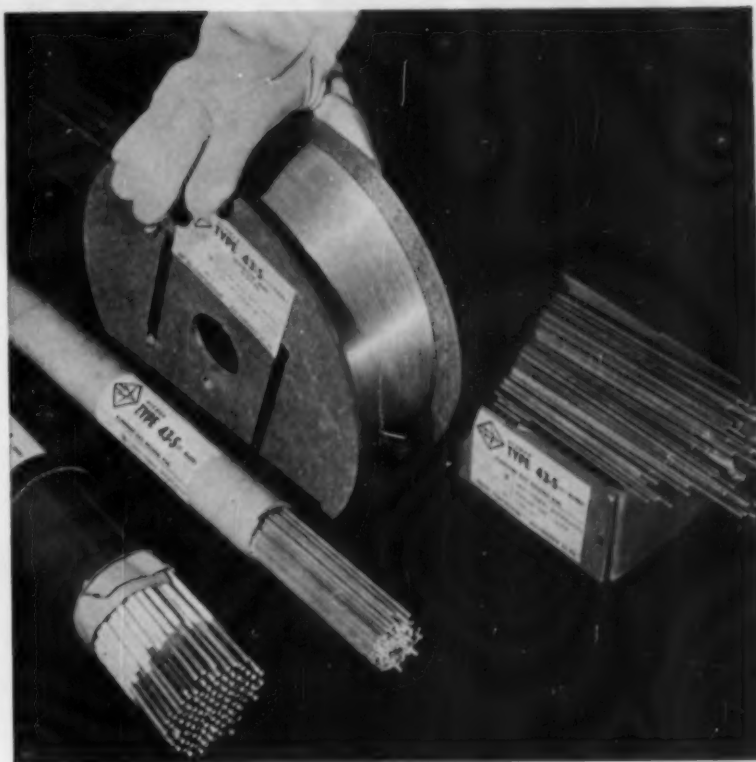
In general, most investigations have shown a strikingly favorable effect of solute alloy additions on creep strength, especially with constant grain size. In many instances, where valences and atomic radii are allowed for, a linear relation has been demonstrated.

In the design of complex alloys for high creep strength the principal objectives have been strengthening by solid-solution hardening, introduction of precipitation hardening, and increasing the thermal softening temperature and the resistance to overaging. The thermal recovery temperature is generally raised more effectively by several alloying elements, each present in small quantity, than by a larger addition of one element which may lower the melting point too much.

The proper combinations of added alloys are also important. Many alloying elements improve the creep resistance much more effectively in steel than in iron. The temperature for maximum strain-age hardening or elastic limit is progressively raised by consecutive additions of carbon, manganese, molybdenum, vanadium and titanium, each being most effective when added subsequently to those previously listed. This is explained on the basis of relating diffusion rates with slip dislocations, each solute having a suitable rate of diffusion for best resistance to dislocation at each stage of creep deformation. This concept is considered to supersede the previous view that precipitation phenomena are most important for improving creep strength. The effectiveness of complex alloy additions is not questioned. It is pointed out that even distribution of the solute elements is important, and segregation, especially at grain boundaries, should be prevented.

Some of the conclusions reached

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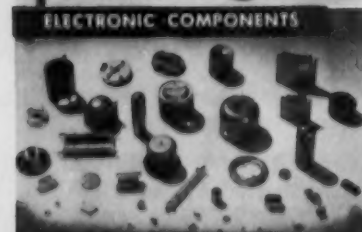
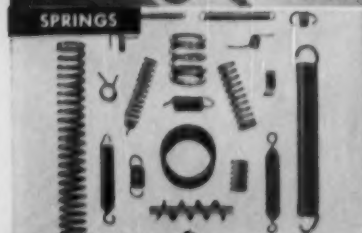
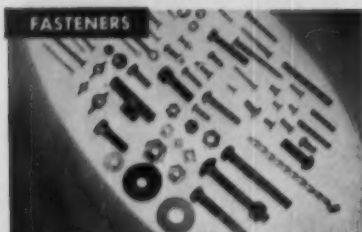
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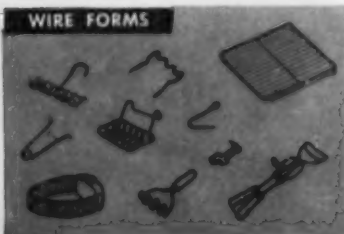


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Alloying and Creep . . .

by the authors in this study are:

1. The hardening effects of lattice distortion in binary alloys can often be used to indicate the solute atoms that are likely to improve creep resistance.

2. Solute atoms that raise the thermal recovery temperature but do not lower the solidus temperature are best for creep resistance.

3. Too high a diffusion rate can be expected to increase creep.

4. Nonuniform concentration of solute atoms between grains and their boundaries may lead to inter-crystalline cracking in creep.

5. Complex alloys give creep resistance over a wider range of conditions than binary alloys do.

6. Metallographic structures may not be primarily important, but only the result of the presence of correct solute elements in appropriate quantity and dispersion.

Sixty-six references and three suggestions for further work are appended to this paper. The latter include suggestions for the determination of the effects of solute atoms on lattice distortion and strain hardening, creep tests on alloys close in composition to temperature-dependent solubility lines, compared with similar alloys just within the precipitation hardening region, and determination of plastic flow in a complex alloy compared with similar measurements on the corresponding binary and ternary systems.

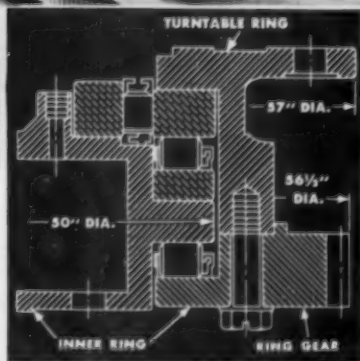
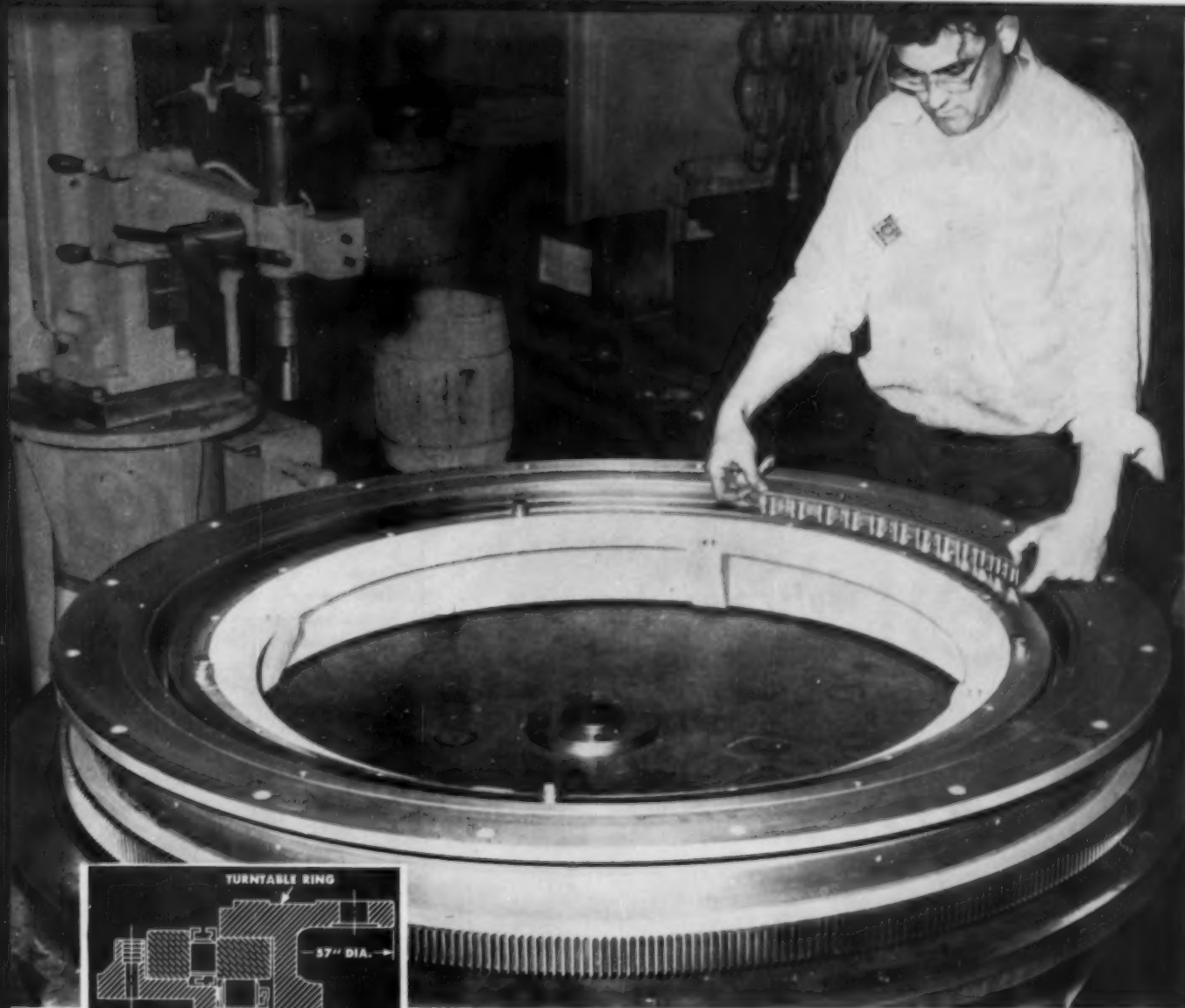
GEORGE F. COMSTOCK

Creep and Aging at High Temperature*

THERE is reasonable agreement among metallurgists that creep in crystalline solids arises from the movement of dislocations through the lattice. Cottrell suggests an interesting and stimulating corollary that the motion of dislocations during creep is dependent in several different ways on various types of

(Continued on p. 156)

*Digest of "Creep and Aging Effects in Solid Solutions", by A. H. Cottrell, Symposium on Creep and Fracture of Metals at High Temperatures, May 31, June 1 and 2, 1954, National Physical Laboratory, Teddington, England.



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Creep and Aging . . .

atomic migrations. Then, on the basis of analyses that confirm this theme, he makes several proposals regarding potential development of highly creep resistant alloys.

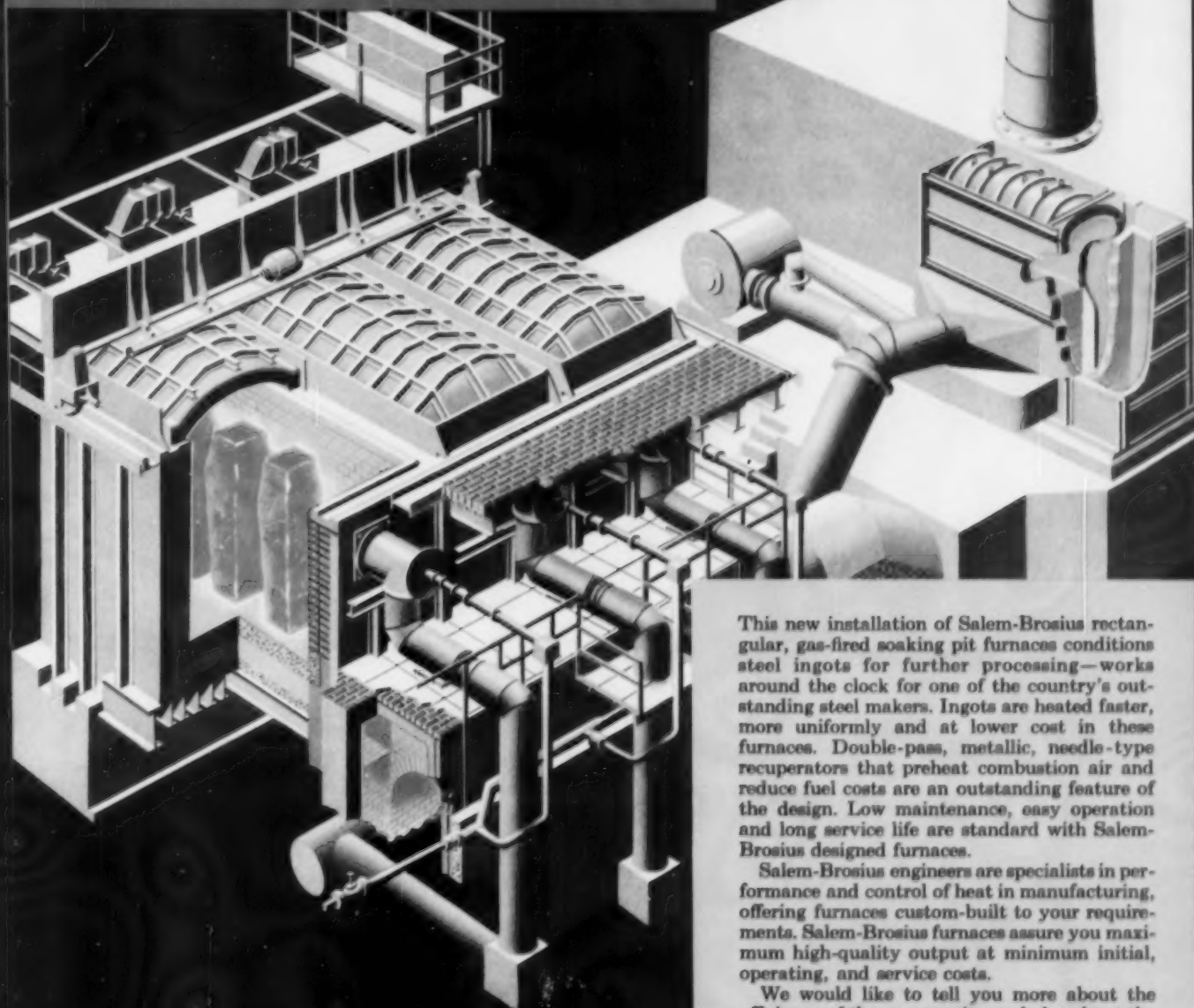
Recovery—The effect of cold work is believed to result in the introduction of vacancies due to the crossing of intersecting screw and edge types of dislocations. The atomic concentration of vacancies is about 10^{-4} times the strain. The nonperiodic electric fields in the region of vacancies cause electron scattering and therefore an increase in electrical resistivity. But after an appropriate recovery anneal, the electrical resistivity can be almost completely restored without causing any significant decrease in the work hardened yield strength. This suggests that vacancies offer practically no resistance to the motion of dislocations. The increase in the self-diffusibility of iron during creep emphasizes that vacancies are introduced by plastic deformation. But at elevated temperatures such excess vacancies can diffuse out of the lattice. Consequently the excess vacancies present during steady deformation at elevated temperatures should be proportional to the strain rate rather than the strain.

Atomic migrations stimulated by the presence of excess vacancies can cause recovery. Evidence of such rapid recovery was presented for high-purity single crystals of aluminum that were pre-strained at 78° K., unloaded, and then strained at 273° K. At 273° K., plastic flow began with an abrupt drop in yield strength of several percent. Since the abrupt drop in yield strength could be eliminated by a low-temperature anneal, the phenomenon could not be ascribed to anchoring of dislocations by solute atmospheres. It was concluded that the introduction of vacancies during straining at 273° K. resulted in catastrophic recovery of the cold worked state introduced at 78° K. It was necessary to anneal for 100 min. at 373° K. to produce the same recovery effect in the absence of straining.

Several investigations reveal that the most creep resistant alloys are also those that are most resistant to recovery. It has been demonstrated

(Continued on p. 158)

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Creep and Aging . . .

that the order of increasing creep resistance in binary ferrites is the order of increasing resistance to recovery, whereas the tensile properties at room temperature follow a different order. Under creep conditions, however, recovery rates are accelerated owing to the excess vacancies that are produced. Recovery at high temperature probably arises from a dislocation climb process involving diffusion of vacancies, whereas recovery at low temperature might be due to thermal relaxation of stresses in the vicinity of piled up dislocations.

Strain-Aging Effects—Additional effects are present in solid solutions on account of interactions between solute atoms and dislocations. Solute atoms will preferentially migrate to those areas about dislocation centers where the free energy is a minimum. At slow rates of deformation and sufficiently high temperatures these solute atom atmospheres can travel with the dislocations. At high rates of deformation and correspondingly low temperatures the solute atoms cannot diffuse with the dislocation. In both of these instances the presence of solute atoms can have only a minor effect on the creep resistance. Over intermediate ranges of temperature and rates, solute atoms will lag behind the moving dislocation under the existing strain-energy gradient. The interaction energy released by this diffusion process is changed to thermal energy and therefore higher stresses are needed to move dislocations in the intermediate range. In this way it was possible to rationalize the humps observed by McGregor and Fisher in the flow stress-temperature curve of a manganese steel, and the plateau observed by Sherby, Anderson and Dorn in similar curves for a series of aluminum alloys. Correlations with creep tests reveal that identical strain-aging phenomena reduce the creep rate over appropriate temperature ranges.

If the rate of dislocation slows, there is more time for atomic jumps to take place and thus further reduce the velocity of the dislocation; if a dislocation is accelerating, fewer jumps can take place and the dislocation continues to accelerate. The
(Continued on p. 160)

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Equivalent number of cyls.	23	1	
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Storage cost (4¢/cyl.)9204	
Handling labor/100 cu. ft.025001	
Storage cost/100 cu. ft.020001	
Cost of product/100 cu. ft.	1.00410	
Cost of equipment/100 cu. ft.	—125*	Amortized in 3 years
Cost of electric power/100 cu. ft.	—060	
Total cost/100 cu. ft.	\$1.045	\$1.597	
Savings in operation/100 cu. ft.448	
Percentage savings in operation cost 44%			
and after equipment is amortized, savings are . . 55%†			

* This figure arrived at by the following assumption: 500 cu. ft.-per hour dissociator costs approximately \$4500 installed. Assume equipment to be completely amortized in 3 years, then amortized cost of equipment equals \$.125 per 100 cu. ft.

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P 3

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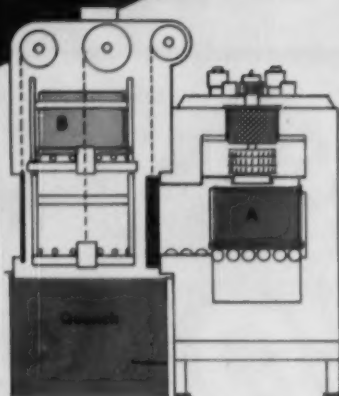
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Sealed Cycle..... A Dow Furnace FIRST for Batch-type controlled atmosphere furnaces.

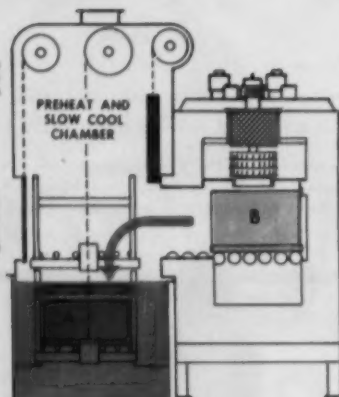
Step 1—LOADING CYCLE

Box A containing full furnace load of parts processing in work chamber. Box B—fully loaded, pre-heats in the upper vestibule. Box C—fully-loaded, waits on conveyor.



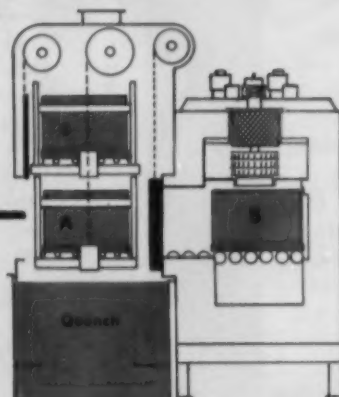
Step 2—QUENCHING CYCLE

Box A completely processed, moves out to elevator and is lowered into quench; bringing pre-heated Box B to loading level. Box B is pushed into heat chamber and door is closed.



Step 3—RELOADING CYCLE

After proper interval, outer door is opened. Box C is placed on upper elevator and raised to pre-heat position as Box A is lifted from quench and removed from lower elevator.



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Creep and Aging . . .

"slow" and "fast" stable ranges of dislocation speeds bracket the intermediate unstable range. These deductions can account for observations on strain-aging effect during creep of zinc single crystals containing soluble nitrogen. During the primary stage, the creep rate decreased abruptly and soon came to an end. The stress was then increased some 10% before creep again started. Yielding occurred in a series of sharp bursts, proving the phenomenon to be ascribable to a strain-aging effect. Thus, dislocations trapped at barriers might be released by a recovery process in pure metals but they might be more or less permanently trapped there by strain aging in alloys. Consequently strain aging leads to a suppression of low-temperature recovery.

The minimum temperature T for strain aging during deformation was estimated to be

$$T = U/R \log_e \frac{(10^4 \epsilon)}{\dot{\epsilon}}$$

where R is the gas constant, U the activation energy for atom-vacancy exchange, ϵ the strain and $\dot{\epsilon}$ the strain rate. By estimating U to be about one-third the activation energy for diffusion, reasonable correlations were obtained with existing data on aluminum, copper and iron alloys.

The maximum temperature of strain aging might be considered to be caused by evaporation of solute atoms from dislocations or to rapid diffusion of the solute atmospheres with the dislocations. Neither of these possibilities coincides with all of the observations.

Precipitation — Theoretically the greatest creep resistance might be obtained by using two distinct precipitating phases, one initially present in stabilized condition to decrease the initial creep strain and a second that can be induced to nucleate precipitation at dislocation centers during creep and thereby restrain dislocations from climbing. It is well known that stabilized precipitates are utilized to produce the highest creep resistant alloys. Recent studies on carbon steels and steels containing Mn and Mo attest to the beneficial effects obtained under conditions that result in additional precipitation of molybdenum carbide during creep.

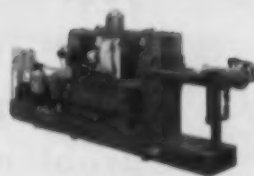
JOHN E. DORN

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The group of aluminum die castings shown here ranges in overall size from a modest 7" x 4-3/4" to a respectable 11" x 8-5/8". The comparable range of weight is 9-1/2 ounces to 1 pound 12-3/4 ounces. A conservative estimate is that this range includes about 80% of all aluminum die castings being made today.

The average die caster would probably schedule these castings on a 400 ton machine. Yet every single one of the castings shown was run on the Lester-Phoenix HP-1-C, rated at 200 tons of clamp-

ing! Just think of the savings in machine-hour-costs that are effected by casting such parts on the comparatively inexpensive HP-1-C.

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Effect of "Early" Cracks on Mechanical Properties*

ACCORDING to the work of P. A. Rebinder and his co-workers, microcracks are generated and grow in both elastic and plastic deformation of crystalline bodies. It can be assumed that at some stage of deformation the microcracks change

into rupture cracks and, depending on a number of factors, variously influence the mechanical properties of the material. In previous papers, the authors stated that in the presence of nonuniform stresses, such as would be produced by twisting after the appearance of macroscopic cracks, plastic metals underwent significant additional deformation, and that these could, in principle, change the state of deformation in the process of rupture in comparison with the state of deformation before the ap-

pearance of the "early" cracks.

In this report, consideration is given to how soon these cracks appear during gradual plastic deformation and how their development is influenced by the stress state. Depending on the conditions of the experiment, the critical size of the "early" cracks and their influence on the mechanical properties of the material will vary over a wide range (for example, in the presence of an active medium). The present tests were done in air.

The following methods were used to create and detect the "early" cracks: (a) A uniform field of cracks along the length of specimen was created by plastic twisting to varying degrees ranging from 25 to 100% of the rupture strength; (b) disclosure of the cracks that developed during twisting was accomplished by plastic stretching of the specimen; (c) a "double specimen" was developed to permit stretching specimens that had been twisted the maximum amount. This specimen consisted of two testing sections in series in a single specimen about twice the usual length. During maximum deformation by twisting, one section of this double specimen would break and the other section could then be tested in tension; (d) the fracture surfaces of a notch-sensitive steel such as 40KhNMA (0.4 C, 0.7 Mn, 0.3 Si, 0.7 Cr, 1.5 Ni, 0.2% Mo) tempered at 390° F. showed clear evidence of early surface cracks when the specimens had been previously twisted to 35% and to 100% of maximum deformation. Such cracks were absent in specimens tested only in tension. When the same steel was made notch-insensitive by tempering at 1020° F. the surface cracks produced by twisting had little influence on the character of its fracture.

Plots of deformation behavior showed that the notch-sensitive steel had almost zero ductility in tension after maximum deformation by twisting. After less severe twisting its ductility was fair in tension but was excellent in compression. The notch-insensitive steel showed fair ductility in tension even after maximum twisting. A. G. GUY

*Digest of "Influence of Cracks on the Mechanical Properties of Material in Various Stress States", by Ya. B. Fridman, T. K. Zilova and N. I. Zhukova, *Doklady Akademii Nauk SSSR*, Vol. 84, 1952, p. 67-70.

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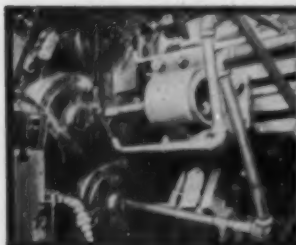
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For more information on the complete line of Cities Service cutting fluids, call in a Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.



Light, Clear Coolant in Acme-Gridley Automatic is Cities Service cutting oil. "Outstanding cooling, anti-weld, and chip drain-off ability," says Jessen. Firm also praises Pacemaker Oils, used in their hydraulic operations.



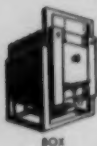
Jessen Mfg. Company, Inc. Mr. Jacob Jessen, Pres., in business since 1923, has earned reputation of keeping on top of new developments. In 1935, he was one of the first to install 6-spindle, anti-friction bearing screw machine.

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MARCH 1955; PAGE 163

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Causes and Prevention of Weld-Metal Cracking*

Part II

IN PART I of this digest (*Metal Progress* for February, p. 146) the important factors affecting the ductility of nonwelded metals were described since they were used as a basis for the study of the same phenomena in welded metals. Two fundamental factors which have been related to weld-metal cracking are the formation of a highly stressed condition and the metallurgical properties of the weld metal. The effects of the various alloying elements and metallographic structures on austenitic and ferritic weld metals were described.

Control of Weld-Metal Cracking

There are a number of methods used to control weld-metal cracking. Most of these are designed to reduce the stress across the weld joint, and some involve metallurgical changes in the deposited weld metal. The human element is a very important factor; a highly skilled welder can do much to eliminate cracking by varying his technique. For years welders have been using stepback, block, and cascade sequence techniques to minimize distortion and cracking. Very little information on these techniques was found in the literature outside of the American Welding Society's "Welding Handbook", Third Edition.

Application of compressive stress on a joint during welding was successfully used in some instances to prevent weld-metal cracking. Usually this method is impractical and it has been discovered that simple changes in welding sequence could be just as effective.

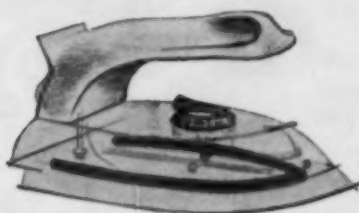
Peening is widely used as a means of minimizing distortion in multipass weld deposits in heavy plates. In multipass austenitic welds, peening is used to break up the columnar grain structure. Although peening does minimize distortion and columnar grain growth, it is believed that it does not have any effect on hot cracking, because it probably

(Continued on p. 166)

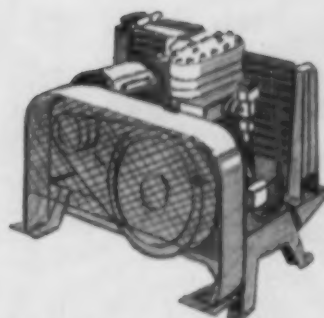
*Digest of "Literature Survey on Weld-Metal Cracking", by A. J. Williams, P. J. Rieppel and C. B. Voldrich of Battelle Memorial Institute, WADC Technical Report 52-143.

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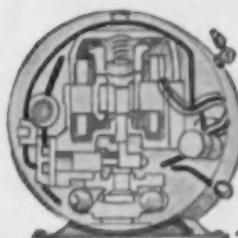


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L-16



Weld-Metal Cracking . . .

occurs long before the peening tool can be applied.

Preheating the work may have two separate functions which could be opposite in their effects: One is the relief of stress on the welded joint which should reduce hot cracking. The other effect is to reduce the cooling rate through the hot cracking temperature range, which should increase the hot cracking tendency. Preheating is beneficial in reducing cold cracking.

Sometimes dissimilar electrodes are used to prevent cracking. The use of austenitic electrodes for welding high-strength ferritic steels was common at one time. Now that the coated low-hydrogen electrodes are available, it is no longer necessary to use austenitic electrodes to prevent under-bead cracking.

It has been noted that when a crack is chipped or ground out and rewelded, the subsequent weld is less liable to crack. The apparent reason for this is that the repair weld is made in the deposited metal and is less diluted by the plate stock. This initiated the practice of "buttering" the scarfed surface of joints with deposits less likely to crack when diluted with the base plate metal. The weld proper is then deposited in the "battered" groove.

Studies of Weld-Metal Cracking

Many different weld cracking tests have been developed because welding conditions are so varied and many particular conditions are encountered in practice. The factors to be taken into consideration in the selection of a weld-metal cracking test are:

1. Reproducibility of the results.
2. Freedom from variation due to the human element.
3. Sensitivity to small changes in a test variable.
4. Ability to show the effects of several welding variables.

The weld-metal cracking tests described in the literature can be classed as four general types: (a) fillet-weld tests, (b) groove-weld tests, (c) controlled restraint tests and (d) tests employing externally applied stress.

The fillet-weld tests include a single-tee joint, a double-tee joint, (Continued on p. 168)

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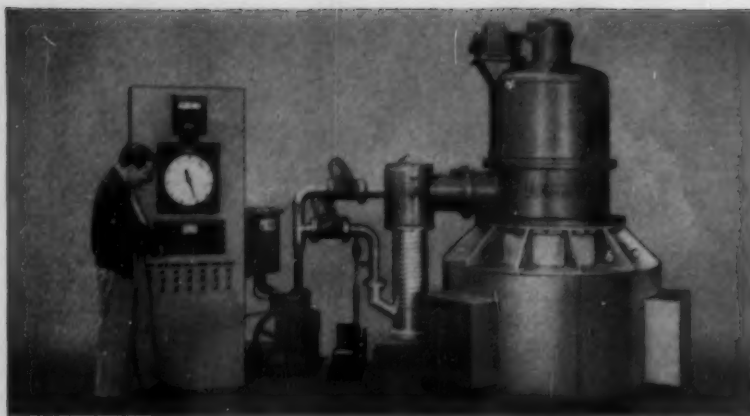
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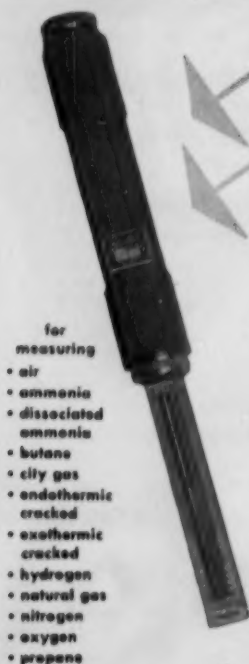
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Weld-Metal Cracking . . .

and a lap joint. All these tests are qualitative and can be adapted or varied in accordance to a particular condition encountered in practice. In all these tests, each successive weld experiences greater restraint than the previous one until defects are discovered.

Groove-weld tests include a restrained butt-joint in which the plates to be welded are bolted to a heavy base plate, an "X" weld (which is a double-vee groove), and a circular patch or groove weld. Weld-metal cracking is more prevalent in these tests than in the fillet-weld tests.

There are three tests in which the restraint is controlled or measured. One of these is the Mond cracking test, in which compression cylinders attached to the welding plates are used to measure forces across the weld and deflections in the jig.

Another such test is the Lehigh restraint test for quantitatively evaluating the degree of restraint at which cracking occurred during cooling. By varying the effective width of a test plate with a standardized groove at its center, the restraint on the weld can be varied. The test has the disadvantage that specimens are expensive to machine and several of them must be used to determine the cracking threshold under a single set of conditions.

The other controlled restraint test is the Naval Research Laboratory specimen. This is a less expensive modification of the Lehigh test. Initial studies of this type of specimen showed that the results were not reproducible because of residual stresses in the specimen due to machining. The only test employing externally applied forces to the weld is the Murex hot-cracking test in which an external bending force is applied to a fillet-weld lap joint during welding. As a result of the bending action, the susceptibility to weld-metal cracking is determined by the relative lengths of the cracks produced.

In summarizing the information found in the survey, one can conclude that the major type of cracking associated with weld metal is the hot cracking which occurs at a relatively high temperature. Very little reliable information is available on

(Continued on p. 170)

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Weld-Metal Cracking . . .

the exact temperature for representative steels or alloys. Most of the cracking is of the interdendritic or intergranular type, regardless of temperature, which may be due to a molten eutectic or liquid impurities at the grain boundaries, or simply due to a hypothetical grain-boundary weakness.

The solution of the problem of the weld-metal cracking would be greatly simplified if more specific knowledge were available to correlate stress conditions and weld-metal characteristics with the cracking tendency. The establishment of such information would go a long way in defining the effective hazards.

E. F. EBLING

Vacuum-Fusion Method for Determining Gases in Cast Iron*

A UNIQUE vacuum-fusion apparatus used for the determination of gases in ordinary cast irons is described in detail. It consists of a fused silica tube immersed in a cylinder filled with water and a high-frequency induction coil, also immersed in water, surrounding the zone of the silica tube in which the crucible holding the cast iron sample is placed. The top of the furnace tube is connected by a ground joint to another silica tube that forms the furnace head. This has a sealed optical window at its top and two side tubes, one above the other, the upper of these being connected to the vacuum system and the lower one having a ground joint for the closed-end tube that stores the samples to be analyzed. Graphite powder (-200 mesh) is poured into the silica tube until it surrounds the crucible to its rim, and the powder is blown out of the crucible.

Procedure for the determinations is as follows:

Samples are cast in a graphite mold and then machined to about
(Continued on p. 172)

*Digest of "Determination of Oxygen, Hydrogen and Nitrogen in Cast Iron", by B. S. Bach, J. V. Dawson and L. W. L. Smith, *Journal of the Iron and Steel Institute*, Vol. 176, March 1954, p. 257-263.

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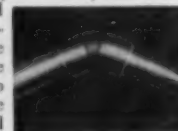


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Tool Steel Topics



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For the North Coast Region, contact your local Bethlehem Steel Sales Office.



Maker of Tableware Likes Economy of Striking Die of Bearcat

A maker of stainless steel tableware had been using striking dies which produced average runs of 19,000 pieces. Good, they thought, but perhaps by experimenting they could find something better. So they decided to switch to Bethlehem Bearcat Tool Steel, then watch their production figures. The number of pieces per die doubled, right from the start.

The Bearcat dies, used in working grade-rolled stainless blanks of varying thickness, are hardened to Rockwell C 56-58. As no redrawing is possible, they are run until failure occurs. The shop superintendent says: "Bearcat is doing a phenomenal job. We particularly like its resistance to shock."

Besides shock-resistance, Bearcat is

well suited for any application where good machining is essential. It is deep-hardening in air, and offers low distortion in heat-treatment. For some applications, it can be carburized easily for long wear.

TYPICAL ANALYSIS

C	Mn	Si	Cr	Mo
0.50	0.70	0.25	3.25	1.40

In addition to its use for striking dies, Bearcat is also ideal for master hobs and engraving dies, used in related industries. You're sure to like Bearcat, no matter where you try it. Why not order a supply today from your local tool steel distributor, or from our well-stocked mill depot.

BETHLEHEM TOOL STEEL ENGINEER SAYS:



You Can Reduce Warpage by Supporting Tools During Heat-Treatment

Warpage of tools in heat-treatment is usually associated with the geometrical shape of the tools, or the manner in which they are supported during heating for the quench. When steels are heated in the critical range, just prior to quenching, they are weak, and if not supported properly, will sag or flow plastically.

Long tools should be supported at frequent intervals along their length. If section changes are present for appreciable lengths, the tools should be supported at each section. However, the span between supports should not exceed three times the tool diameter.



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Vacuum-Fusion . . .

1 in. long and 3/8 in. diameter, weighing about 20 g. each. After machining, the samples are degassed in the vapor of boiling carbon tetrachloride, weighed, and immediately placed in the sample tube. After the assembly is completed and sealed, the system is evacuated and then the crucible is gradually heated to 4350° F. The furnace is degassed for 3 hr. at 3630° F. under a vacuum of less than 1 micron (10⁻⁴ mm. Hg). The temperature is then dropped to 3000° F. and a Toepler pump is operated to remove absorbed gas as the blank evolution over a period of 1 hr. is determined. If the blank volume is satisfactory (less than 0.02 ml. total gas per hr.), the specimen is brought into the crucible by means of a magnet. As the sample melts, the gas is collected in the Toepler pump and removed after 15 min. Occasionally, especially with samples containing much nitrogen, gas evolution is slow and may require up to 45 min.

After many preliminary test runs on this equipment, it was found that the results were affected by the method of sampling, by internal porosity (which is especially common in gray iron), and by rusting of the sample. The results indicated that the influence of absorbed gas on a sample surface varied with the porosity and amounted to about 5 × 10⁻⁴% for oxygen and about 10 × 10⁻⁴% for nitrogen. Highly porous iron always gave high and variable gas contents; to overcome this difficulty only sound samples of this type of iron may be analyzed with reliability. The effect of storing the sample either in air or in vacuum was found to be negligible.

As a result of these factors, an open-topped graphite mold giving 3 cylinders 1 1/8 in. long and 9/16 in. diameter was used to make the cast samples. Samples of gray iron cast in sand as keel-block bars were analyzed but a variation was often found in these test pieces, especially from the center of the keel-block bar. Results of hundreds of determinations are tabulated in the paper. Also reported is a comparison of the results obtained on sand cast and chill cast samples for each of eight analyses.

(Continued on p. 174)

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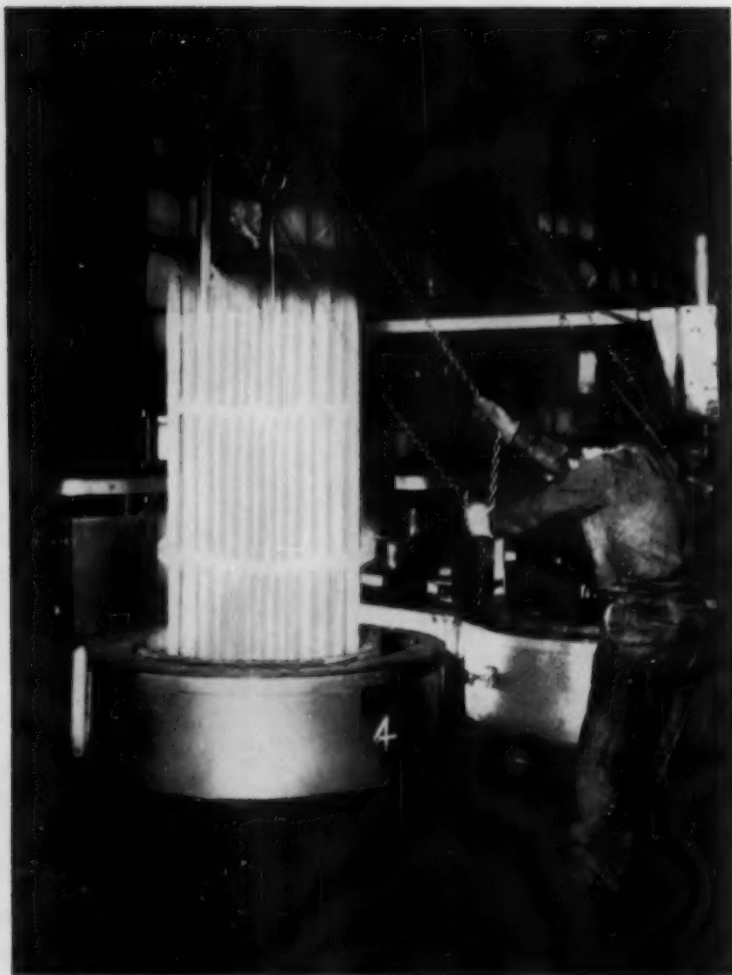
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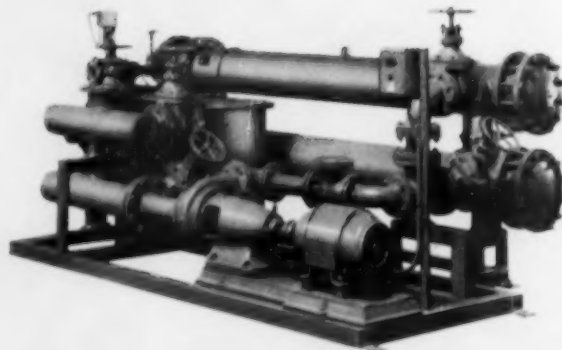
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gen contents were determined by chemical methods on the same samples.

As a result of these investigations, it was decided that the special type of chill cast sample was the most reliable for the determination of oxygen and nitrogen in cast iron. At the present, however, very little reliance is placed on results of determinations for hydrogen. The problem of determination and sampling of hydrogen in cast iron is still under investigation.

Numerous samples analyzed by the above techniques gave very satisfactory results. One doubt that arose during the work was in connection with nodular cast iron made by treatment with nickel-magnesium alloy. Very low oxygen contents were obtained (2 to $5 \times 10^{-4} \%$), and it was wondered whether MgO , if it were present, would be reduced by carbon under the conditions used. Sloman had already shown that silicon, aluminum and manganese would be reduced and the same calculations were applied to MgO . These showed that MgO should be reduced completely at $2820^\circ F$. To check for complete reduction, other samples were reduced at temperatures up to $3270^\circ F$. The same results were obtained and it was felt that the low results obtained are in fact true figures for magnesium-treated iron.

E. C. WRIGHT

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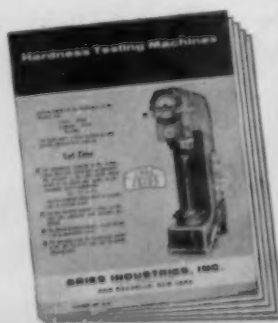
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Diffusion of Nitrogen in Alpha and Gamma Irons*

DIFFUSION coefficients of nitrogen in iron at 500 and $600^\circ C$. (930 and $1110^\circ F$.) are derived by the authors from the desorption rates of nitrogen from iron wires in hydrogen, using internal friction measurements to determine concentration ratios. The solubility of nitrogen in austenitic steels is so great that its presence in such alloys is not detrimental because nitrogen stabilizes the gamma phase. The solubility of nitrogen in ferritic steels is so small that its presence is always harmful on account of the aging effects it causes.

The internal friction determinations were made on the purest iron wires available. Pure iron was melted and cast in a vacuum in the form of rods 14 mm. (0.4512 in.) diameter; these were then cold swaged and cold drawn to 0.7 mm. (0.0276 in.) diameter. Lengths of about 12 in. of this prepared wire were nitrided by heating to $950^\circ C$. ($1740^\circ F$.) for 3 hr. in a gas stream of $99\% N_2$ and $1\% H_2$. After nitriding, the wires

(Continued on p. 176)

*Digest of "Diffusion of Nitrogen in Iron", by J. D. Fast and M. B. Verrijp, *Journal of the Iron and Steel Institute*, Vol. 176, January 1954, p. 24-27.

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Diffusion of Nitrogen...

were quenched in water, reheated for 10 min. at 560° C. (1040° F.) in pure nitrogen, and again quenched in water. The authors state that the nitrogen content of wires was about 0.025% (0.10 at. %) after this treatment; the final grain size of the wire was about one-tenth the diameter of the wire.

Immediately after the last quench the internal friction peak was measured by testing the wires at different temperatures between -20 and 60° C. (-4 and 140° F.). The wires were used as the suspension element in a torsional pendulum system with a period of oscillation of 1.3 or 5.7 sec. The logarithmic decrement was determined during the decay of the torsional oscillations. Charts showing the damping peaks against temperature are shown in the paper. The mathematical equations for calculating the internal friction are also given.

The diffusion coefficient of nitrogen at the temperature of maximum damping can be calculated from the time of relaxation. The diffusion co-

efficients at 500, 600 and 950° C. were determined by studying the rates of desorption of nitrogen. Desorption was accomplished by heating wire samples at 600° C. in hydrogen and at 560° C. in pure nitrogen after loading the wire with 0.1 at. % nitrogen. The internal friction peak at 21° C. (69.8° F.) of the loaded wire was about four times as great as that of the wire treated in hydrogen and about 2½ times as great as that of the wire homogenized at 560° C. in pure nitrogen. In these tests the wires were first loaded with nitrogen to 0.1 at. % N₂ and tested at 21° C.; next, heated in wet hydrogen gas at 500, 600 and 950° C. and tested at 21° C.; and finally, each of the wires after the three previous treatments was heated to 560° C. in pure nitrogen and tested at 21° C. It was found that the desorption in hydrogen gave a false damping peak due to surface denitrication and the homogenizing treatment corrected this.

The diffusion coefficients at 500, 600 and 950° C. determined experimentally by the internal friction measurements and those calculated

from theoretical concepts were found to be in close agreement. Complete equations are included in paper.

A remarkable fact observed in these tests is that the diffusion coefficient of nitrogen in alpha iron is much greater than in gamma iron. At 540° C. (1005° F.) the diffusion coefficient of nitrogen in alpha iron is greater than in gamma iron at 950° C. The extrapolated value of the diffusion coefficient for alpha iron at 950° C. is 50 times greater than for gamma iron.

Most important is the fact that the values of the diffusion coefficient at 9.5 and 21.5° C., as calculated from the authors' internal friction measurements, correspond well with the values (for the same temperatures) obtained by extrapolation from the region 500 to 600° C., where conventional diffusion experiments were carried out. This forms a strong support for the correctness of the interpretation of damping caused by carbon and nitrogen as given by Snoek and Polder. Similar support is derived from the combined measurements of Stanley and Wert.

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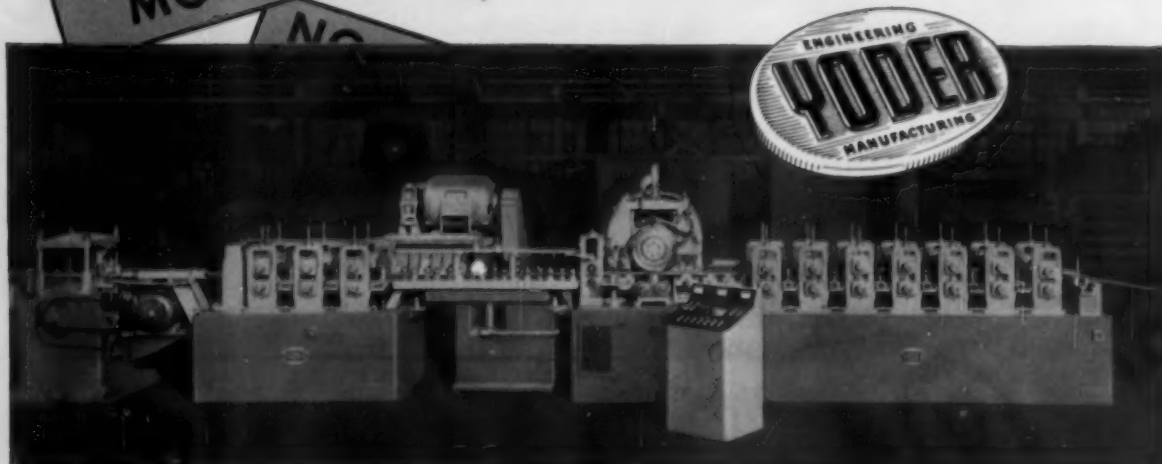
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1.50% max	65/68%	18/20%
2.00% max	65/68%	15/17.5%
3.00% max	65/68%	12/14.5%

VANCORAM FERROMANGANESE BRIQUETTES are recommended for use in iron as a manganese addition agent and also as a desulphurizer. Their shape is oblong for swift identification, their weight is approximately 3 pounds per briquette for easy handling, and their manganese content is exactly 2 pounds for simple addition without weighing.

The Briquettes are furnished in convenient palletized form, if required, thus simplifying handling and storage and reducing contamination.

Whether you make your additions to furnace, cupola or ladle . . . you'll consistently get better, more uniform results when you use Vancoram Silicomanganese Alloys or Vancoram Ferromanganese Briquettes.

FORGING TECHNICIANS—Yes, that is the compliment paid us by those acquainted with our services. In back of each design is a thorough understanding of engineering and metallurgical needs before production begins . . . assuring forgings of maximum physical properties and uniform quality

THE LANDING GEAR FORGING illustrated, nearly five feet long, is an important component for a modern military fighter . . . another example of Wyman-Gordon's technical contribution to aircraft.

There is no substitute for Wyman-Gordon experience

WYMAN-GORDON

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER, MASSACHUSETTS

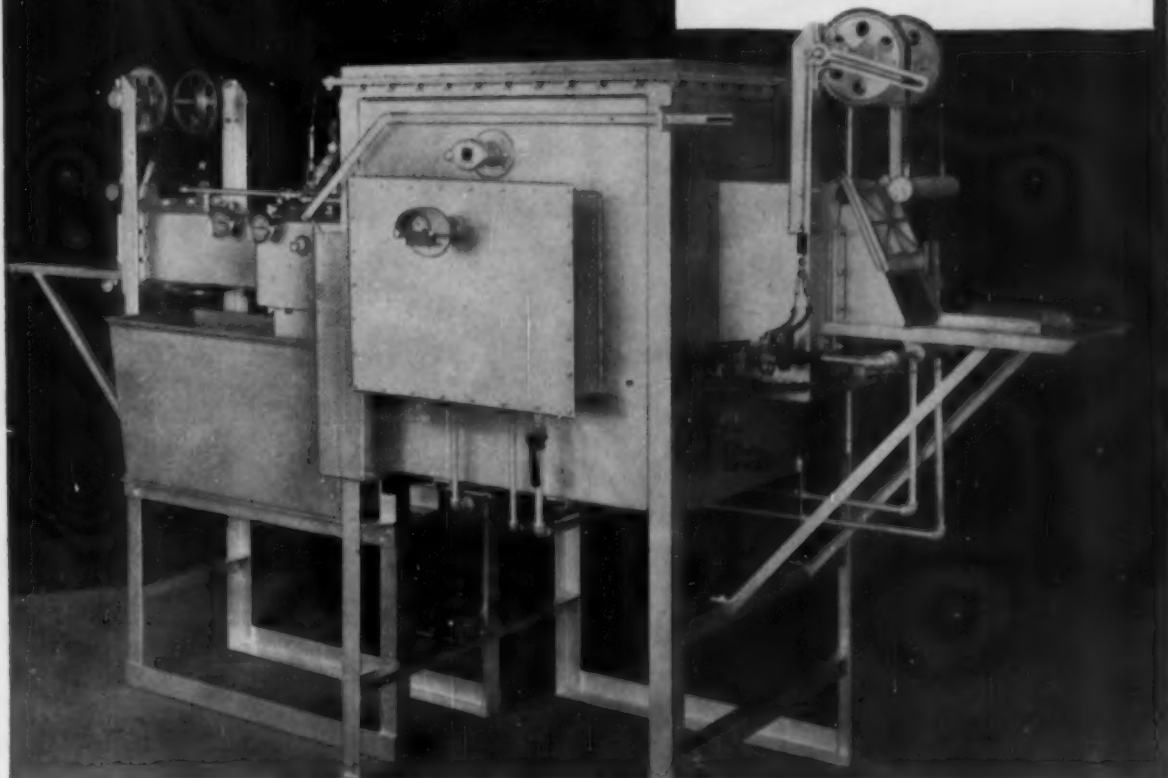
HARVEY, ILLINOIS

DETROIT, MICHIGAN

C. I. HAYES selects GLOBAL® Heating Elements

CONTINUOUS PUSHER TYPE FURNACE

● Built by C. I. Hayes, Inc., Cranston, Rhode Island, for heat treating high speed steel tools. GLOBAL non-metallic heating elements assure dependable service during peak loads.



GLOBAL Silicon Carbide Heating Elements used in this modern heat treating furnace provide an ample margin of safety at the normal operating temperature. This assures dependable performance and low maintenance cost on regular production schedules, plus

the handling of peaks in production without danger of costly breakdowns.

GLOBAL elements provide clean, silent and safe heat. Elements may be installed or removed quickly and easily...while the furnace is at temperature.

GLOBAL® Heating Elements give you...

- 1 **MORE HEAT...** per unit area of hearth.
- 2 **WIDEST RANGE OF TEMPERATURES...** up to 2750°F.
- 3 **SIMPLICITY** of furnace construction.
- 4 **LESS DOWNTIME...** no need to cool or unload during replacement.



OUR ENGINEERS have worked closely with furnace manufacturers and users for over 30 years, to help provide the most modern, efficient and economical equipment for all industrial heating processes. For complete information on the many advantages of GLOBAL Heating Elements —and how they can help solve *your* heating problems—write The Carborundum Company, Dept. MP 87-57, Niagara Falls, New York.

GLOBAL®

Heating Elements

by **CARBORUNDUM**

REGISTERED TRADE MARK
62-17



How to Select the Most Economical Insulating Firebrick

The advantages of lightweight insulating firebrick over ordinary "heavy-weight" firebrick are generally known to furnace operators and furnace builders. But many buyers have wondered just what advantages there might be in one brand of insulating firebrick as against another. The answer to this question could very well mean savings in fuel costs, increased furnace output, longer life . . . or all three.

One furnace builder ran tests on their small electric kilns where heat input could be measured with great accuracy. Here's what they found: B&W IFB required 25% less heat than any other brand of insulating firebrick they tried.

The reason? B&W IFB are lighter in weight than any other insulating firebrick—they contain more tiny, insulating air cells. Heavier, denser insulating firebrick linings waste fuel two ways: They soak up and store more heat which is lost when the furnace is cooled; and they conduct more heat through the walls.

How about long life? One of the



toughest tests of firebrick is in the lining of a carbon monoxide furnace. Some brands last only a few weeks, then disintegrate, due to iron oxide impurities in the brick which react with the gas.

But B&W Insulating Firebrick contain little iron oxide, and they're processed at high temperatures so that any traces of iron oxide form stable compounds. So instead of deteriorating they stay on the job year after year—in many cases over 10 years.

Another factor, important to many furnace operators, is accurate temperature control. Here again B&W IFB have an advantage over other insulating firebrick. First, because B&W IFB are lighter in weight they store and conduct less heat—and they respond more quickly to changes in heat input.

A typical example is the giant stress-relieving furnace shown below—sixty feet by twenty-two feet by seventeen feet high. The B&W lining plays a vital part in holding the desired temperature within 5 degrees accuracy!



Next time you buy or specify insulating firebrick, remember that the lightest weight brick of all—B&W—has the highest insulation value, the longest life and the greatest furnace heat controllability.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York 17, N. Y.
Works: Augusta, Ga.

TUTHILL PUMP COMPANY EXPERIENCES...

"NO FAILURES

SINCE USING

STRESSPROOF®

SEVERELY COLD-WORKED, FURNACE-TREATED
STEEL BARS

SAVES MONEY, TOO!"

● Tuthill knows the rotor is the heart of their pump. Quality cannot be compromised. For more than 10 years, Tuthill has used STRESSPROOF for rotors (replacing heat-treated alloy steel) without a failure!

Strength is required in these rotors to transmit the power through the shaft to the idler gear. Extremely high operating speeds mean the rotors must be straight. Wearability is an absolute necessity if the rotors are to stand up under severe operating conditions.

STRESSPROOF has all of these qualities. In addition, it is readily machinable. Its in-the-bar strength eliminates heat treating with its distortion, cleaning and subsequent machining problems. No rough machining, heat treating and finish machining with STRESSPROOF. The rotors are finish-machined from the bar.

STRESSPROOF's minimum warpage eliminates all straightening operations in this case. Its wearability keeps the rotor running year after year. It also provides real savings in both material and manufacturing costs.

STRESSPROOF makes a better part at a lower cost.

AVAILABLE FROM LEADING STEEL DISTRIBUTORS
COAST-TO-COAST



LaSalle STEEL CO.

1424 150th Street, Hammond, Indiana

MANUFACTURERS OF AMERICA'S MOST COMPLETE LINE OF
QUALITY COLD-FINISHED STEEL BARS



Tuthill Model L Series mechanically sealed pumps are used in lubricating, hydraulic, transfer and burning oil service. Capacities range from 1/3 to 6 g.p.m. at pressures up to 600 p.s.i. The rotors for these dependable industrial pumps are made from LaSalle STRESSPROOF.

WRITE TODAY FOR

helpful data bulletin No. 15...
"Improve
Quality —
Cut Costs"

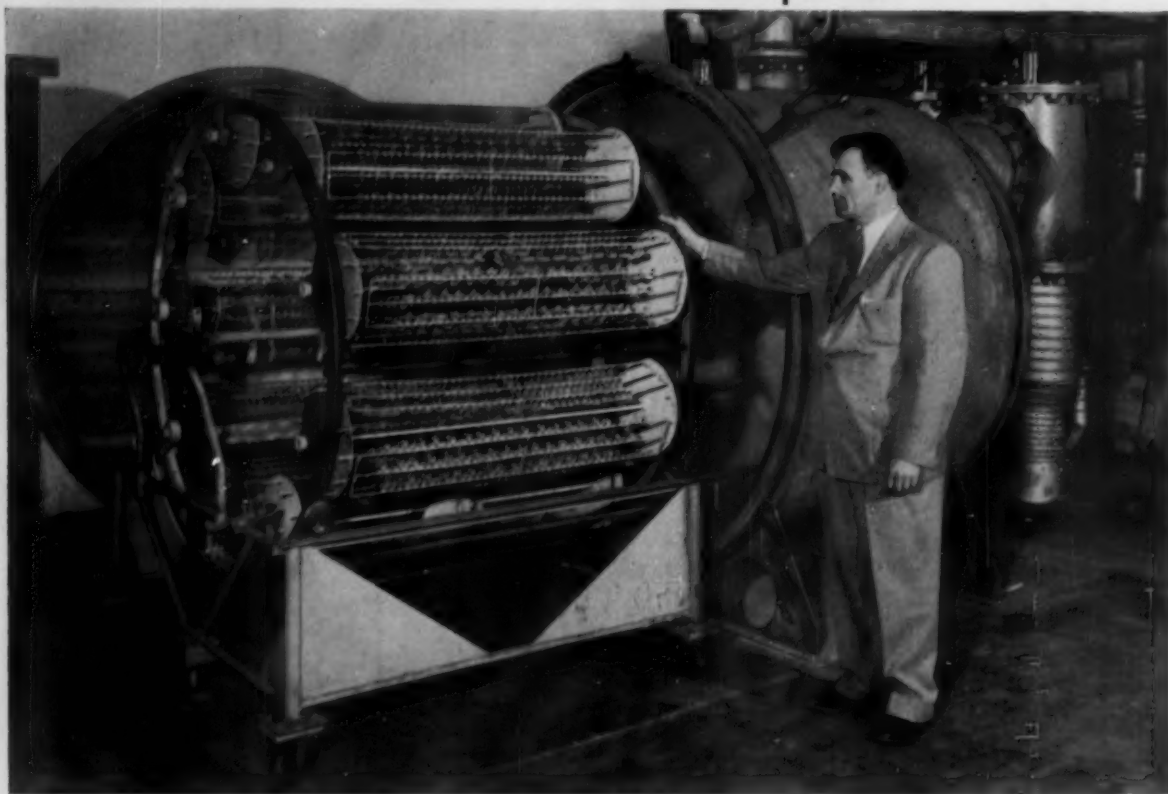


*"Here's the Fastest Cycling,
Easiest Operating Vacuum
Coater I've Ever Used",*

says

**Mr. John Guleserian,
President**

Vacuum Plating Co.,
Providence, R. I.
Regal Plating Co. Inc.,
Providence, R. I.



Mr. Guleserian points out the easy-loading, "shadowless"
Planetary jig in his NRC Rapid Cycle Vacuum Coater.

"Only one man is needed to slide this jig in and out. The mechanical pump is unaffected by the stickiest weather. The pumping system is easy to maintain . . . no booster pump used . . . one drum of mechanical pump oil lasts a year. The electrical power connections to the filaments are made automatically when the jig is inserted to eliminate operator error — a problem of

other coaters I've seen. This NRC Rapid Cycle Vacuum Coater is a number one producer," says Mr. Guleserian.

Let us help you plan your complete vacuum coating process set-up. We can give you advice on dolly design . . . lacquer choice . . . size of coater and help in laying out your process to return the greatest profit to you.



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How To Solve Corrosion Problems



PROBLEM: Valving sulphur-laden flue gas at 800 deg. F. and 300 psi.

REMEDY: A 1/8-in. layer of HASTELLOY alloy B was applied to seats and seating surfaces.

RESULT: The valves gave over four years' service despite the corrosive conditions.

PROBLEM: Protecting a preheater from corrosive attack during periodic contact with hydrochloric acid, trichlor benzene, and other chlorine compounds at 300 deg. F.

REMEDY: Complete lining with HASTELLOY alloy C 11-gage sheet.

RESULT: The vessel has given four years' service and is still going strong.



Free: Money-saving jobs like these are described in detail in the monthly magazine HAYNES ALLOYS DIGEST. To receive a copy regularly, write Editor, HAYNES ALLOYS DIGEST, Room 308, 30 East 42nd Street, New York 17, New York.

HASTELLOY *alloys*

Trade-Mark

Nickel-base, corrosion-resistant alloys available as sheet, plate, bar stock, welding rod, welded tubing and pipe, cast pipe and pipe fittings, sand and precision-investment castings.

"Hastelloy" is a registered trade-mark of Union Carbide and Carbon Corporation.

Haynes Stellite Company

A Division of

Union Carbide and Carbon Corporation

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TOUGH HEAT TREATING JOB?

here's a belt to lick it

Perhaps you've thought your heat treating operation is one that's too tough for spiral belts.

If so, here's big news for you. New and improved Wissco Rod Reinforced Belts are built extra big and rugged . . . to carry heavy loads through the furnace.

Wissco's IMPROVED THIN SPIRALS effectively resist stretch and distortion. DUAL CONTINUOUS REINFORCING RODS put an end to narrowing. And Wissco's 1/4-inch Rod Reinforced Every Spiral Belt will stand up under severe heavy-duty demands.

We can furnish improved Wissco Reinforced Every Spiral Belts in any high-temperature alloy to meet your particular heat treating problem.

THE COLORADO FUEL AND IRON CORPORATION—Denver and Oakland
WICKWIRE SPENCER STEEL DIVISION—Atlanta • Boston • Buffalo
Chicago • Detroit • New Orleans • New York • Philadelphia

2579

WISSCO BELTS

PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION 

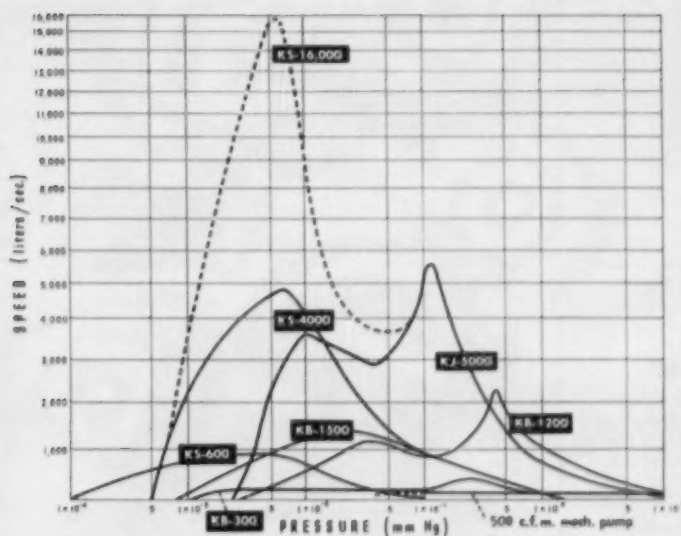
Belt illustrated, actual size

These **CVC** pumps ...

are working in these vacuum metallurgy installations

KB-300	→	Titanium Sponge Production
KS-600	→	5-50 lb. Melting and Casting
KB-1200	→	1000 lb. Consumable Electrode Arc Melting
KB-1500	→	Multi-Batch Carbide Sintering
KS-4000	→	350-500 lb. Melting and Casting and Arc Melting 8" dia. ingots
KJ-5000	→	1000 lb. Melting and Casting at 3 to 25 microns pressure
KS-16,000	→	1000 lb. Melting and Casting at 0.8 to 15 microns pressure

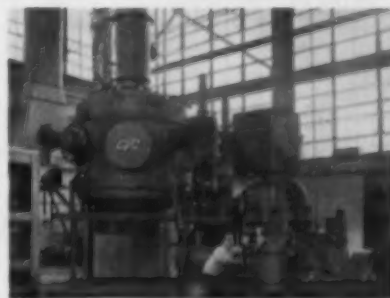
and here's how they work



If you work or plan to work in vacuum metallurgy, you can profit by *CVC's* practical experience in the field.

CVC is currently designing, building and installing high vacuum furnaces which solve many unusual problems. The wide range of pumps used in these installations and the know-how we have obtained from our work with them can go far in helping to solve your problems.

We welcome the opportunity to discuss high vacuum metallurgy with you. For further information and a copy of our "Information Memo" on High Vacuum Metallurgy write to *Consolidated Vacuum Corporation, Rochester 3, N. Y.* (a subsidiary of Consolidated Engineering Corporation, Pasadena, California).



This 1000-lb. high vacuum melting and casting furnace is an example of efficient, economical design. The buyer is starting with 350-lb. melts. The 4800 liters-per-sec. speed of a

single KS-4000 pump is more than adequate for 350-lb. melts (see graph). When he's ready for 1000-lb. melts, he simply adds another KS-4000 pump and a 1000-lb. coil and crucible.



Consolidated Vacuum Corporation

ROCHESTER 3, N.Y.

Headquarters
for High Vacuum

sales offices: NEW YORK, N. Y. • CHICAGO, ILL. • BOSTON, MASS. • SAN FRANCISCO, CALIF. • CAMDEN, N. J.



News about COATINGS for METALS

Metallic Organic Decorative Protective

Protective plastisols gain new versatility

Make shorter work of finishing problems

When up against a finishing problem, many engineers and designers like to get the opinions of a finishing specialist. They prefer to consult a company that knows many types of finishes.

Because United Chromium has developed plating processes, specialized organic protective coatings, and a wide line of chromate finishes, it can be a real help in suggesting the best type of finish to meet service, appearance and cost requirements.

ELECTRODEPOSITED COATINGS

Unichrome Copper, Nickel and SRHS Chromium comprise the first matched set of plating processes. This means one source, one responsibility for proper operation which in turn means the finest finish of its kind plus smoother running production.

UNIQUE ORGANIC COATINGS

Developed to meet unusual requirements, Unichrome lacquers, synthetics, enamels are now available in a broad range to block corrosion, add long life to the eye appeal of a product.

CONVERSION COATINGS

Chromate treating strengthens corrosion resistance of zinc die castings and plate. It offers an easy, economical way to finish. With Unichrome Dips, high quality also is obtainable—quality measured in durability and appearance.

• • •

More information is as close as the United Chromium office nearest you.

UNITED CHROMIUM, INCORPORATED

100 East 42nd Street, New York 17, N. Y.
Waterbury 26, Conn. • Detroit 20, Mich.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.

Advantages of Unichrome heavy-duty vinyl compounds now obtainable even with sprayed coatings



Thick, flexible film



Resilient and crack-proof



Resists many corrosives

PLASTISOL compounds are liquids, which when heat cured, build up vinyl plastic finishes that look and feel like rubber, but there the resemblance ends. Plastisols offer truly remarkable chemical resistance, which is further fortified by the tough, substantial film thickness achieved in one coat.

SEAMLESS, THICK-FILM PROTECTION

Any metal surface that can be uniformly baked can now be strongly protected against severe and corrosive service conditions by Unichrome 4000 Series Plastisol Compounds—or the new Coating 5300. The first practical sprayable plastisol, Unichrome Coating 5300 fills the need for a plastisol suitable for application to products too large to be dip-coated.

A 20 mils thick, non-sagging coat can be applied even to cold vertical surfaces in just one application with

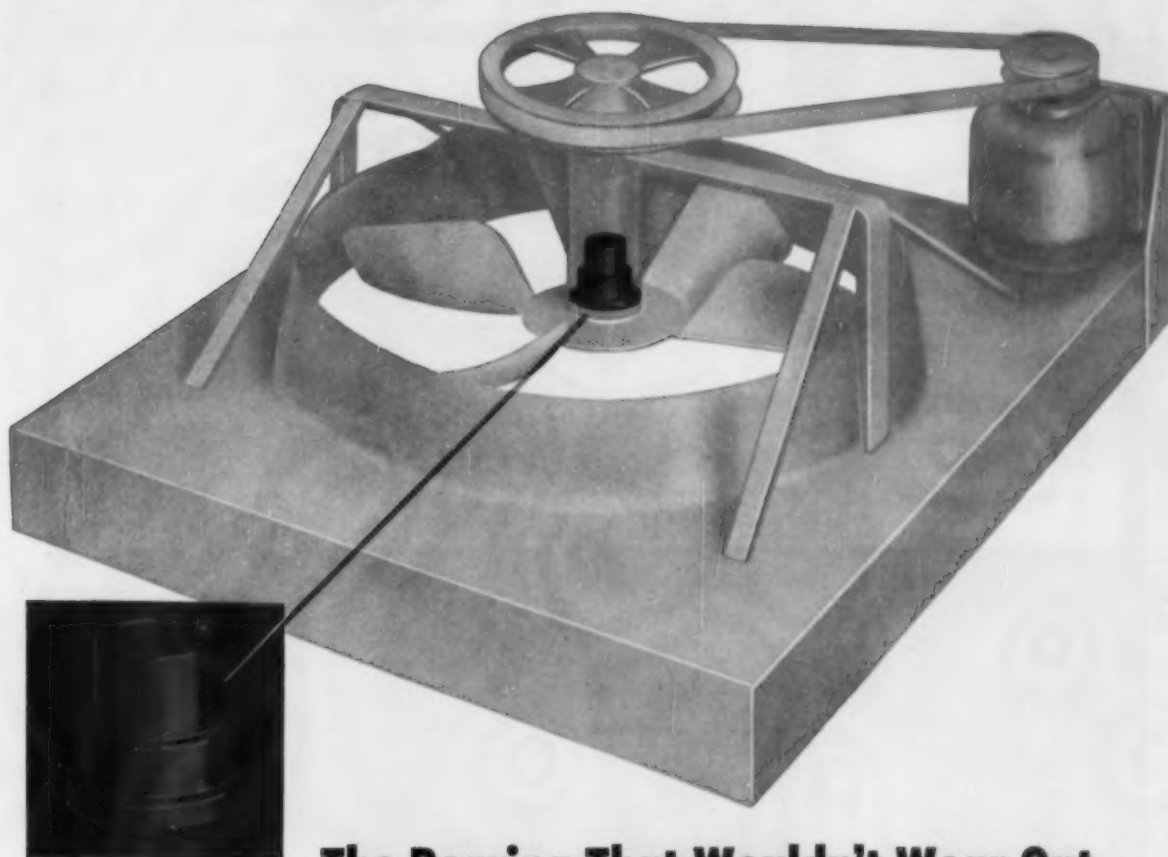
Coating 5300. That's 5 to 20 times thicker than ordinary coatings. Unichrome Series 4000 Plastisols, which are applied by almost any other conventional method, produce coatings up to $\frac{3}{16}$ " thick. Plastisols can do jobs for which sheet materials have been used.

CHEMICAL RESISTANCE OF VINYL

Unichrome Plastisols offer seam-free and pore-free protection against acids, alkalis, water, salt solutions and many other corrosive agents. They bake into an abrasion-resistant resilient coating that doesn't crack, chip or tear. With such protection, ordinary metals can often be used in place of costly alloys.

The chemical resistance, physical toughness, electrical insulating properties, and speed of curing of Unichrome Plastisols combine to offer engineers a new tool for protection and finishing. Send for Bulletin VP-1.

IN POWDER METALLURGY . . . IT'S AMPLEX



The Bearing That Wouldn't Wear Out 125 years* service without adding a drop of oil

How long will a bearing last? An OILITE customer making large vertical shaft attic fans wanted to know the answer. He subjected a fan equipped with an OILITE bronze flange bearing to an "accelerated life test equivalent to 125 years of service. Throughout the test it ran quietly and smoothly. *Not one drop of oil was added—it showed no apparent wear.*

OILITE bearings hold oil by capillary attraction. Oil film on the surface insures positive, constant lubrication. Particularly good in trouble areas where lubrication is difficult or impossible. The built-in oil cushion allows OILITE Heavy-

Duty Bearings to absorb shocks and stresses.

Heavy-Duty, self-lubricating OILITE bearings are Chrysler engineered to meet individual requirements. Standard bearings are available from local dealer stocks. Also cores, bars, plates, discs and strips in sizes ranging from $\frac{1}{8}$ " to $15\frac{1}{4}$ " I.D. and 1" to $18\frac{1}{4}$ " O.D.

The engineering facilities of Amplex and Chrysler, unmatched in the powder metal industry, are ready to help you with your bearing problems. For on-the-spot service, consult your telephone yellow pages for the field engineer near you.

CHRYSLER AMPLEX PRODUCTS

OILITE Bearings

Permanent Metal Filters

Finished Machine Parts

Friction Units

Write for free 24-page
OILITE Bronze Precision
Bearings bulletin B-53.



Only Chrysler makes OILITE

CHRYSLER CORPORATION • AMPLEX DIVISION

Dept. H-3

Detroit 31, Michigan



the "New Look" in Lead*

***ONE-TON INGOT**



Method of handling and stacking one-ton lead ingots by means of fork lift truck.



One end of freight car loaded with 50,000 lbs. of lead in units of 25 one-ton ingots.

THE ST. JOSEPH LEAD COMPANY is now ready to ship corroding lead to carload consumers in units of one-ton ingots. This "new look" in lead has been worked out successfully with a number of our customers who have now adopted it as a standard practice for their shipments. Assuming adequate melting capacity, the shipping of lead in one-ton ingots offers consumers these obvious economies:

• Strapping charges for the 2000 lb. to 2500 lb. "bundles" are eliminated.

- Shifting, dislocation or "scrambling" of cargo, due to strap breakage is avoided.
- Since delivery in "neat" package is ensured, handling costs and injury hazards are greatly reduced.
- Ingots are adapted to easy handling with ordinary fork lift trucks, and can be picked up from either direction.
- The compactness of one-ton units also makes possible a considerable increase in storage capacity.

For improved materials handling at less cost, specify one-ton lead ingots for your shipments.



ST. JOSEPH LEAD COMPANY

The Largest Producer of Lead in the United States

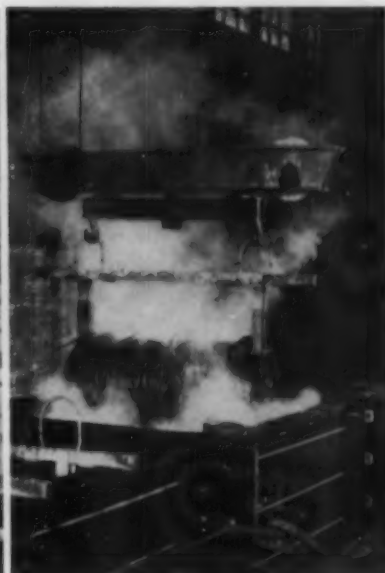
250 PARK AVENUE, NEW YORK CITY 17, NEW YORK



TOOL STEEL SHEETS



STAINLESS STEEL BAR STOCK



CARBON STEEL WIRE

You can safely descale most metals in 20 minutes or less

WITH THE DU PONT SODIUM HYDRIDE PROCESS



In 10 to 20 minutes, sheets, bars, wire, rods, forgings and fabricated articles are completely descaled with the Du Pont Sodium Hydride Descaling Process. Even heavily scaled forgings ($\frac{1}{2}$ " scale thickness) take less than an hour. And in only 15 seconds you can get cold reduced-

annealed strip clean and bright!

With hydride descaling, there's never any danger of etching or pitting . . . never a costly reject due to loss of gauge. Base metal is always protected, *since bath action stops the instant scale is reduced*. And retreatments are rarely needed with most metals. One pass through the sodium hydride bath will do the job completely.

TECHNICAL SERVICE AVAILABLE

If you are descaling metals which are unaffected by fused caustic at 700°F., it will be to your advantage to talk to us about the Du Pont Sodium Hydride Process. Du Pont pioneered this modern descaling method and can bring a depth of technical experience to bear on your descaling problems.

There's no cost for this service which includes laboratory investigation of problems, plus expert aid in construction, installation and operation of the process. Just call our nearest district office or send in coupon below.

DISTRICT AND SALES OFFICES: Baltimore • Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Kansas City* • Los Angeles • New York • Philadelphia • San Francisco
*Baroda & Page, Inc.

FOR MORE INFORMATION



E. I. du Pont de Nemours & Co. (Inc.), MP-8
Electrochemicals Dept., Wilmington 98, Del.

- ☐ Please send me your free booklet on Sodium Hydride Descaling.
☐ Please have one of your technical men call. I am interested in descaling _____

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Firm _____

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City _____ State _____

Du Pont | **Producer of Sodium**
| **Pioneer of Hydride Descaling**



BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

Improved Metal Flow with Controlled Fast Heating

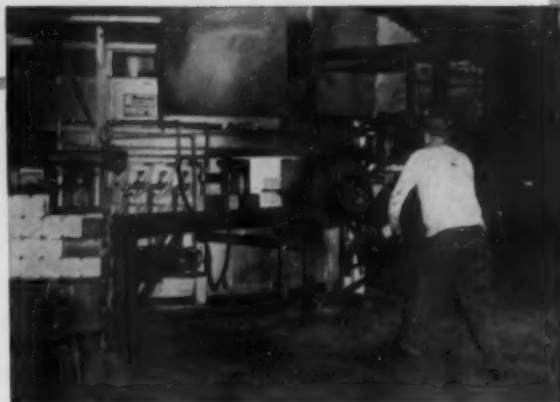
Mill installations of high-speed gas heating furnaces for hot working operations are proving that steel heated rapidly—with no soak—exhibits improved metal flow beyond that of steel heated slowly and soaked. In the light of this experience, gained over the past decade, industry today is taking a new look at the benefits of controlled fast heating.

Selas high-speed heating techniques develop forging temperatures at rates from one to five minutes per inch of thickness, which compares with conventional practice of 20 to 40 minutes per inch. Operations in the field and laboratory demonstrate that steel, uniformly exposed to the high temperature heat source providing the fast heat transfer rates, will not rupture or develop defects which sometimes result in conventional heating practice.

Heating the center of a bar or billet to forging temperature by controlled fast heating can result in a temperature gradient, surface to center. This is beneficial, because it overcomes the surface-heat loss which occurs during transfer from furnace to work-station, thus equalizing the temperature and providing a uniformly-heated billet for the hot working operation.

Improved forgeability, directly attributable to the rapid heating, reduces power requirements at the usual forging temperatures, or, for given power applied, permits an increase in the amount of flow or deformation. More importantly, this increased capacity for hot work can be used to advantage to permit working the steel at lower temperatures, with no increase in applied work.

Surface chemical reactions, producing decarburization and scale, are reduced to negligible values by controlled fast heating. The short time under heat and the lower hot working temperatures are prime factors, since they minimize exposure of the steel in the higher heat range where surface reactions proceed at an accelerated rate. Another important factor is atmosphere regulation, wherein free oxygen is eliminated from the products of combustion to minimize the oxidizing potential of the furnace gases. This is accomplished by pre-mixing gas and air in a Combustion Controller and delivering to the burners at a fixed ratio and constant pressure.



Lansdowne Steel and Iron Company at Morton, Pa., prominent producers of shells for ordnance, are utilizing this new method of rapid gas heating for hot forging and realizing the many benefits attendant to such practice. A radiant, burner-fired rotary furnace, used for heating billets up to 6 inches square, and with a production rate of 8000 pounds per hour, is shown in the above photograph. Another similar furnace, designed for billets up to 3 inches square, is also in use.

This plant has found it possible to reduce the forging temperature from 2100°-2200° F to 1800°-1850° F using the same presses formerly employed for the higher temperatures. Tests conducted by Selas engineers, utilizing strain gauges attached to the press columns to record press loads, establish that billets heated rapidly to 1850°F, with no soak, require no more press loading than billets heated to 2150°F, with one hour soak, for slugging and backward extrusion operations. Further, billets heated rapidly to 1850°F, with no soak, require approximately 30% less press load than billets slow heated to 1850°F with one hour soak.

Rapid heating to the lower forging temperatures has eliminated the descaling operation. Reduced temperatures and scale elimination have increased die life substantially. Also, the uniformity of heating and scale reduction have accounted for a ten per cent reduction in billet weight. Other benefits of the method are reduced labor costs (automatic furnace control, one operator loads and unloads billets), improved production (furnace paces the press) and decreased floor space requirement of the furnaces.

Selas Corporation of America
Philadelphia 34, Penna.



Get the "PACKAGE"

when you buy HEAT TREATING SALTS!

Houghton's research staff works closely with metalworking plants—often side by side with your heat treaters—in servicing salt baths.

So valuable ingredients that are not in the formula go with every Houghton Salt you buy—wide knowledge of your heat treating problems and on-the-job service that helps you solve them!

Houghton Liquid Salt Baths cover a temperature range of 350° F. to 2400° F.—for tempering, martempering, annealing, quenching, carburizing, nitriding, normalizing and hardening of ferrous and non-ferrous metals.



Ask the Houghton Man for help he'll gladly give you—or get for you—to assure fast, uniform metal treatment batch after batch. Or write to E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa., for latest "Liquid Salt Baths" book.

LIQUID SALT BATHS

... products of

E. F. HOUGHTON & CO.
PHILADELPHIA • CHICAGO • DETROIT • SAN FRANCISCO



Ready to give you
on-the-job service ...

GLC CARBON BRICK

For Blast Furnace Operations

Significant characteristics of
GLC CARBON BRICK are ...

- ➔ Strength and abrasive resistance at high temperatures
- ➔ Dimensional stability
- ➔ Low thermal expansion
- ➔ Thermal shock resistance
- ➔ Resistance to slag build-up
- ➔ Non-melting by liquid metals

You can depend upon Great Lakes
carbon brick for optimum performance.

ELECTRODE  DIVISION

Great Lakes Carbon Corporation

GRAPHITE ANODES, ELECTRODES, MOLDS and SPECIALTIES

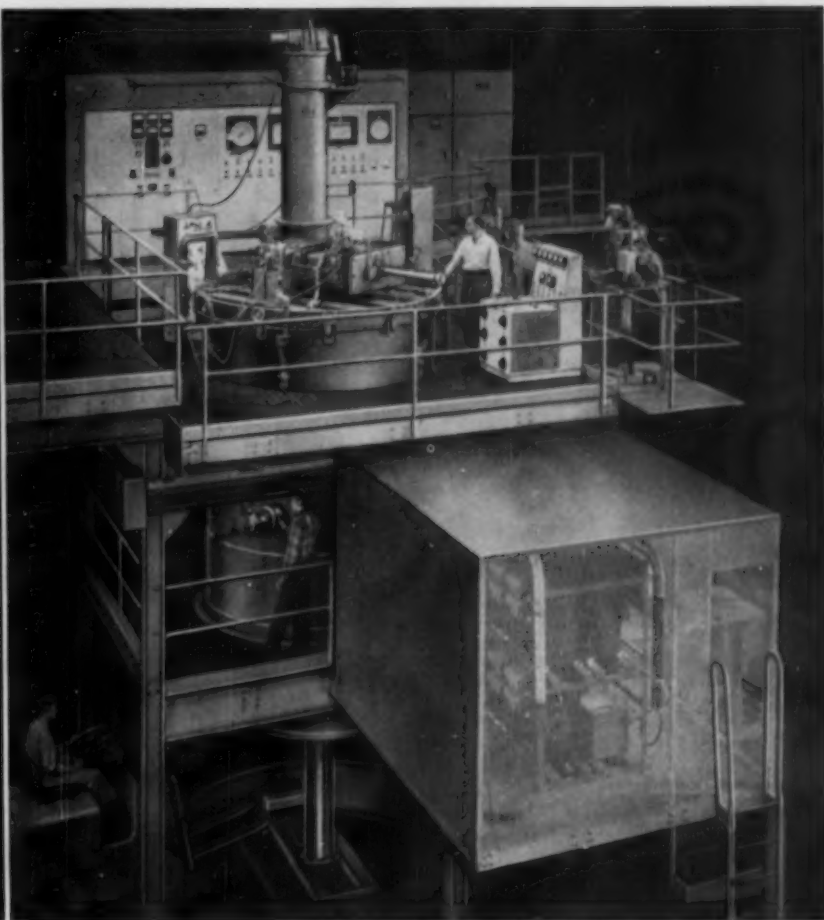
ADMINISTRATIVE OFFICE: 18 East 48th Street, New York 17, N. Y.

PLANTS: Niagara Falls, N. Y., Morganton, N. C.

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SALES AGENTS IN OTHER COUNTRIES: Great Northern Carbon & Chemical Co., Ltd., Montreal, Canada
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*what
made
vacuum
melting
work?*



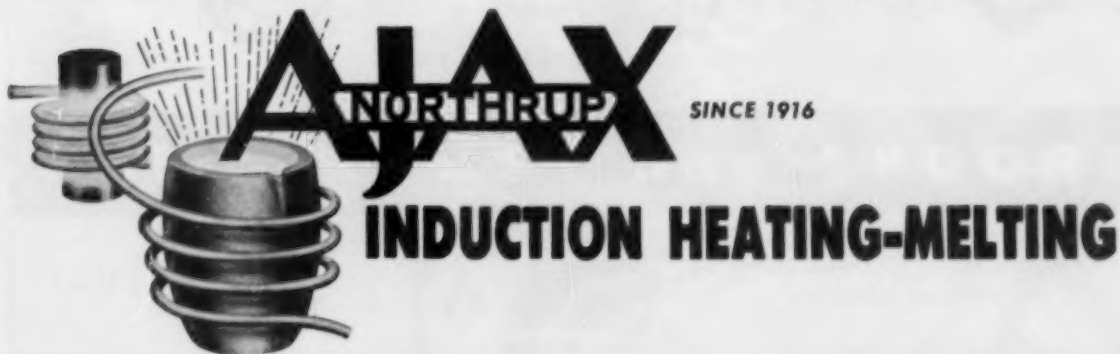
*The first 1000-lb. vacuum furnace to be put into production.
Photo courtesy Universal-Cyclops Steel Corp., Bridgeville, Pa.*

primarily—newly discovered vacuum techniques applied to forty years of induction furnace manufacturing experience. And only at Ajax does this experience cover so many melting developments over such a long period of time. Successful vacuum melting, as it comes from Ajax today, is just

another refinement in Ajax quality melting at production speed.

The vacuum furnace illustrated above is typical of a number which are now being built for purer, stronger alloys in capacities from 5 to 2000 lbs. For details, write Ajax Electrothermic Corp., Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.



COMPLEMENTARY METALS



MAGNESIUM and TITANIUM

Magnesium gives you
good strength with
EXTREME LIGHTNESS



Titanium gives you
EXTREME STRENGTH
with good lightness

One metal complements the other. B&P has broadened its scope-of-service to the light metal industry by developing methods and adding facilities for the fabrication of Titanium. For information or advice regarding your possible uses of these Companion Metals, write or phone B&P.



Engineering
and Design
in Magnesium
and Titanium



Rolling
Magnesium
Sheet and
Plate



Fabrication
and Assembly
of Magnesium
and Titanium

BROOKS and PERKINS Inc.

1958 W. Fort St.,

Detroit 16, Mich.

TAshmo 5-5900



LIGHTNESS... *PLUS!*

CrysCoat*



MOVES IN THE BEST CIRCLES

*The Oakite CrysCoat
Cleaning-Phosphating Process
for preparing metals for painting

SHAW-WALKER steel desks and filing cabinets are *time-engineered* to make office work quick and easy. Beneath the piano-like baked enamel finish of this fine office furniture is a protective coating of CrysCoat to make it look better . . . last longer.

There's an Oakite CrysCoat Process to suit your particular set-up:—

1. Zinc phosphating in spray washer
2. Zinc phosphating in tank
3. Iron phosphating in spray washer
4. Iron phosphating in tank

Each CrysCoat Process gives you a fine phosphate foundation for long-lasting paint adhesion.

Each CrysCoat Process protects against corrosion under the paint.

Each CrysCoat Process is easy to control.

Each CrysCoat Process is solidly backed by nationwide Oakite Service that unconditionally guarantees satisfaction.

Illustrated literature describing the Oakite CrysCoat Cleaning-Phosphating Process gladly mailed on letterhead request.

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Approach
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Testing
Problems

How to test electrical insulators simultaneously for mechanical and insulating efficiency is a problem that was recently given to Olsen testing engineers. The solution: a standard Super "L" universal testing machine with special insulation that permits use of high voltage current with complete safety for both the operator and the machine.

This is just one example of hundreds of unusual testing requirements solved by Olsen using the incomparable SelecRange Indicating System—standard in all Olsen hydraulic Super "L" and electro-mechanical Electromatic testing machines. These industry proved machines are unmatched for testing speed, accuracy, ease of operation, dependability and adaptability.

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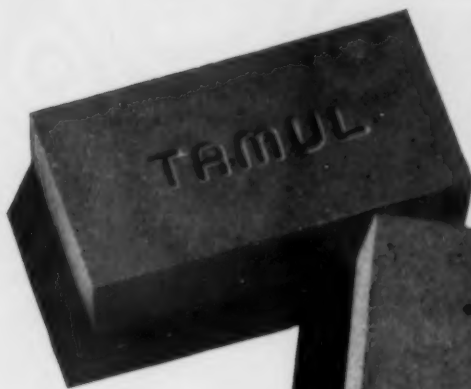


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P.C.E.I. Cone 38-39 (3335-3389°F.)
Al₂O₃ Content: 66-68%
Available as Brick, special shapes



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Al₂O₃ Content: 88-90%
Available as Brick, special shapes, specialties



Based Purest commercial grade zirconium silicate
P.C.E.I. Above Cone 42 (above 3659°F.)
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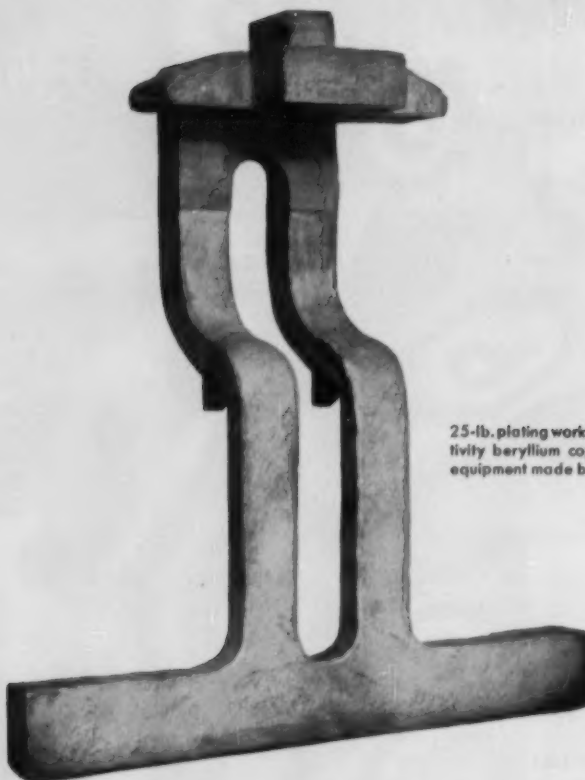
Additional data on these brands with recommendations on applications will be gladly supplied on request. Contact your Taylor field engineer or write us direct.



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THEY'RE MADE OF BERYLLIUM COPPER

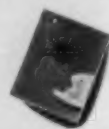
The increased amperage called for in modern plating equipment demands higher conductivity in this casting—a contact which rides on a copper bus bar and transmits current from the bar to the plating tanks. Various materials used in the past, although they had the required wear resistance, lacked the conductivity for this application. To get around the problem, engineers considered brazing a strip of high-conductivity "Berylco" beryllium copper to the part.

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control accuracy $\pm 2^{\circ}\text{F}$.
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as described by Mr. Fred Hansen

Vice President, Manufacturing and Engineering

"A committee, of which these Metals Engineers are members, must approve any change in specifications and materials before any purchase orders can be placed. Based on experience with metal performance in manufacturing and service, they decide on suppliers. Our Metals Engineers, of course, do a lot of research on the behavior of materials on which buying of metals, ceramics, instruments, alloy castings and expendable products is based and approved.

"Customers come to us with engineering problems involved in their own production. Our men are dealing with their opposite numbers therefore, the Metals Engineers in our customers' plants. Being able to try out our own products in our commercial heat-treating production is very helpful to Lindberg Engineering Company."

Regarding Metal Progress Mr. Hansen says, "Metal Progress, like the Metal Show, has proved to be an excellent place to introduce something new."

Magazine of 26,000
Metals Engineers

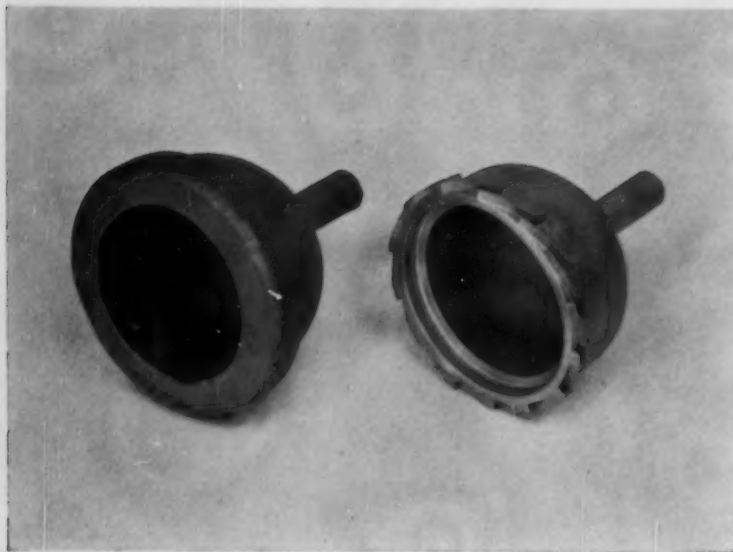
Metal Progress

A publication of the American Society for Metals
Owner and Manager, National Metal Exposition

7301 Euclid Avenue, Cleveland 3, Ohio

These Metals Engineers are discussing the final test of a Lindberg carbonitriding furnace. Left to right: Mr. C. H. Stevenson, Vice President, Sales; Mr. Roy Lindberg, President; Mr. Norbert Koebel, Director of Research; Mr. Fred Hansen, V. P., Manufacturing and Engineering. All are members of American Society for Metals and readers of Metal Progress.

What's the Right X-ray Film?

**PRODUCT:**

Nozzle for jet plane's air conditioner.

MATERIAL:

Aluminum Alloy 355, 1/2 in. thick

EQUIPMENT:

140 k.v. x-ray machine

Kodak Industrial X-ray Film, Type A

FOURTEEN curved vanes are machined in the rim of this aluminum casting. It's foolhardy to "guess" if castings are sound and defect-free, machining costs are too great.

So, all rough castings go to the radiographer to be x-rayed. For these radiographs he uses 86 k.v. at a distance of 48 inches, 45 seconds exposure time.

The film selected is Kodak Industrial X-ray Film, Type A.

This film gives him high contrast with little graininess. It's fine for examination of light alloys with short exposures at low voltages. Also has sufficient speed to use with high voltage equipment in radiographing thick or dense materials.

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Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage—heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

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Burning Issues

Eclipse

Published by Eclipse Fuel Engineering Co.
Rockford, Illinois

Good news for die casters

By R. E. HAYDEN

"If you are considering the purchase of melting equipment to produce better aluminum castings easier and reduce your costs, here are some facts worth considering.



"First, the new Eclipse Double-Chamber Dry Hearth Furnace eliminates gas pick-up. Since metal is charged to the dry hearth, all moisture is driven off during the melting process. There is no overheating of metal because the metal flows into the holding bath as soon as it is melted, and the temperature is easily and accurately controlled by a thermocouple in the dip-out vestibule.

"Second, oxide inclusions are eliminated, too, because the small amount of oxide formed is not carried into the molten metal but is left on the hearth where it can be removed at the end of the working day. In fact, there is very little oxide produced because there is no stirring of metal in the holding bath. The slight film formed on top of the metal actually protects molten metal and reduces the amount of oxide produced.

"Third, operator comfort has been designed into every dimension of the furnace. The hearth is only 36 inches from the floor, and only cold metal need be handled. It is easy to clean, and keep clean, because aluminum will not adhere to the brick. Dip-out vestibule, only 30 inches off the floor, is located away from furnace heat. And there is much less heat from the dip-out than from a pot or crucible.



and refractory maintenance is negligible. Let us send you a copy of Bulletin C-80-T describing the variety of sizes and styles available."



R E Hayden

Sales Manager, Furnace Division

Eclipse Fuel Engineering Co., 1127 Buchanan St., Rockford, Ill.
Eclipse Fuel Engineering Co. of Canada, Ltd., Toronto, Ont.

METAL PROGRESS; PAGE 208

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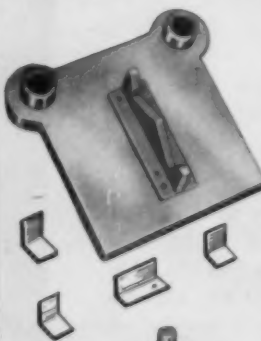
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WARD Machinery Co. 564 West Washington Chicago 6



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FACT:

This completely automatic billet heater cuts forging costs . . . ups production

These specific advantages tell why:

Scale Loss—0.6% is typical—60 to 80% less than other heating methods, *because* the speed and precision of Westinghouse induction heating doesn't give scale a chance to form.

Maintenance Costs—80% reduction is not at all unusual, *because* Westinghouse design gives you high availability—minimizes maintenance labor costs.

Down-Time Production Loss—Extremely low down time of Westinghouse induction heating equipment compared with other heating methods means less lost production.

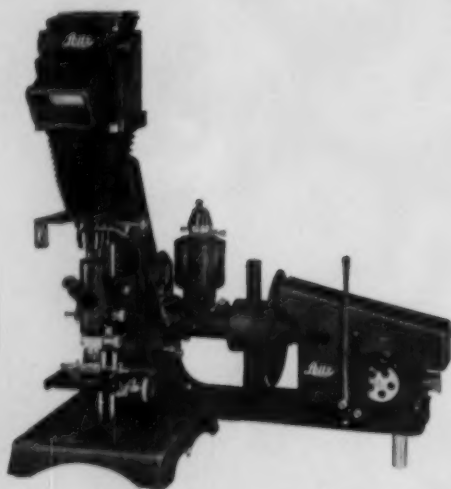
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Other Advantages, including significant space savings; cool, clean working conditions; quick start-up and very low stand-by losses, combine to make Westinghouse induction heating your best investment in advanced, lowest cost billet heating. For sound advice on reducing *your* forging costs, call The Man With The Facts—your Westinghouse sales engineer. And—ask him for your copy of booklet B-6519, or write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pennsylvania. J-02295

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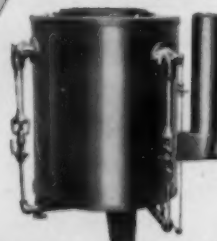
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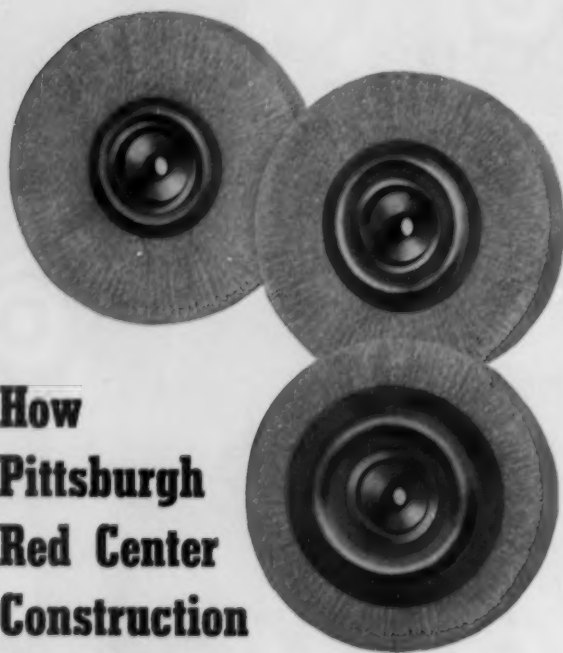


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METAL PROGRESS; PAGE 212

THE KING PORTABLE Brinell HARDNESS TESTER

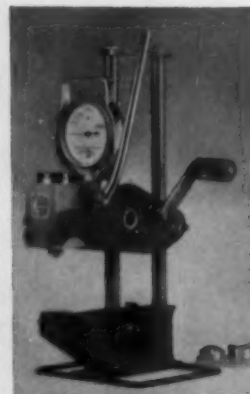
Offers You More Outstanding Advantages Than Any Other Hardness Tester

The King PORTABLE Brinell Hardness Tester is an important member to add to your production team because it saves handling and set up time and permits fast, accurate readings. In addition, this versatile unit:

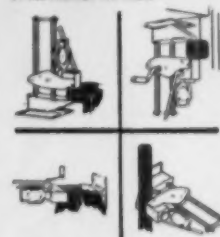
1. is guaranteed to make Brinell tests of the greatest accuracy
2. can be taken to the work or used as a bench tester
3. puts a load of 3000 kg. on a 10 mm ball—other loads as required
4. can test materials in any position almost anywhere—even small cramped spaces
5. has a removable test head to test parts of any size
6. eliminates test bars—there's only one impression to read
7. is especially adapted for testing immovable parts and parts in assembled machines

Ask for the folder illustrating and describing other advantages of this widely used precision tester.

Andrew  **KING**

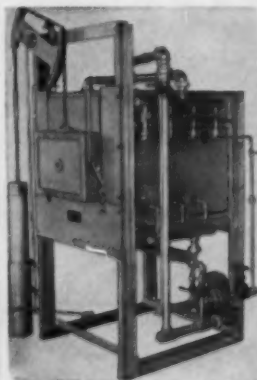


Weight is only 26 lb. with the base, 10 lb. without the base.



The King Portable can be used in any position—even upside down.

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The entire shell of the bucket on this 50-cu. yd. power shovel is fabricated from $\frac{3}{4}$ " and $\frac{6}{16}$ " "T-1" Steel Plate. Liner plates are made of $\frac{1}{2}$ " "T-1" Steel. "T-1" Steel Plate only $\frac{6}{16}$ " thick has replaced large castings a foot thick in the lip of the bucket. Lighter weight construction with "T-1" Steel made it possible to increase the cubic capacity of the bucket by ten yards.



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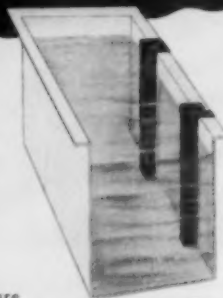
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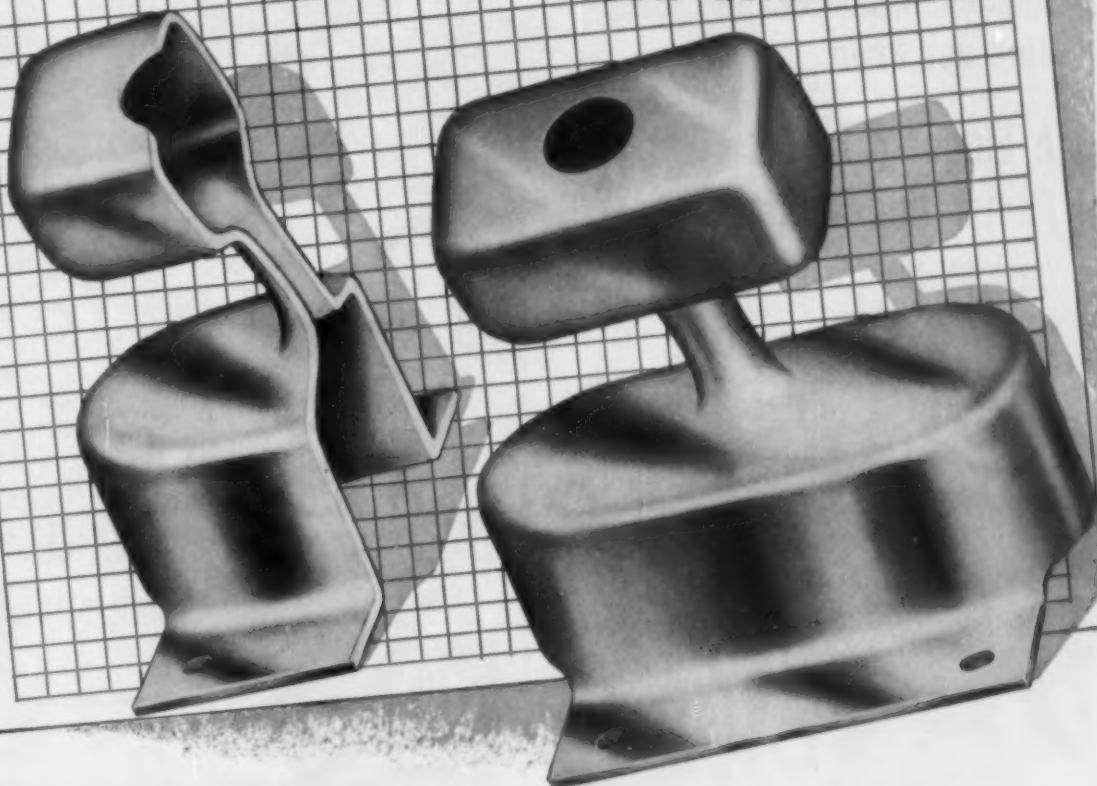
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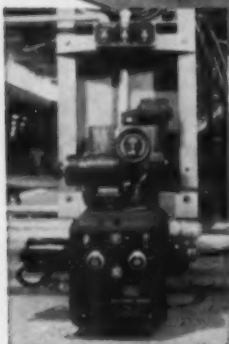
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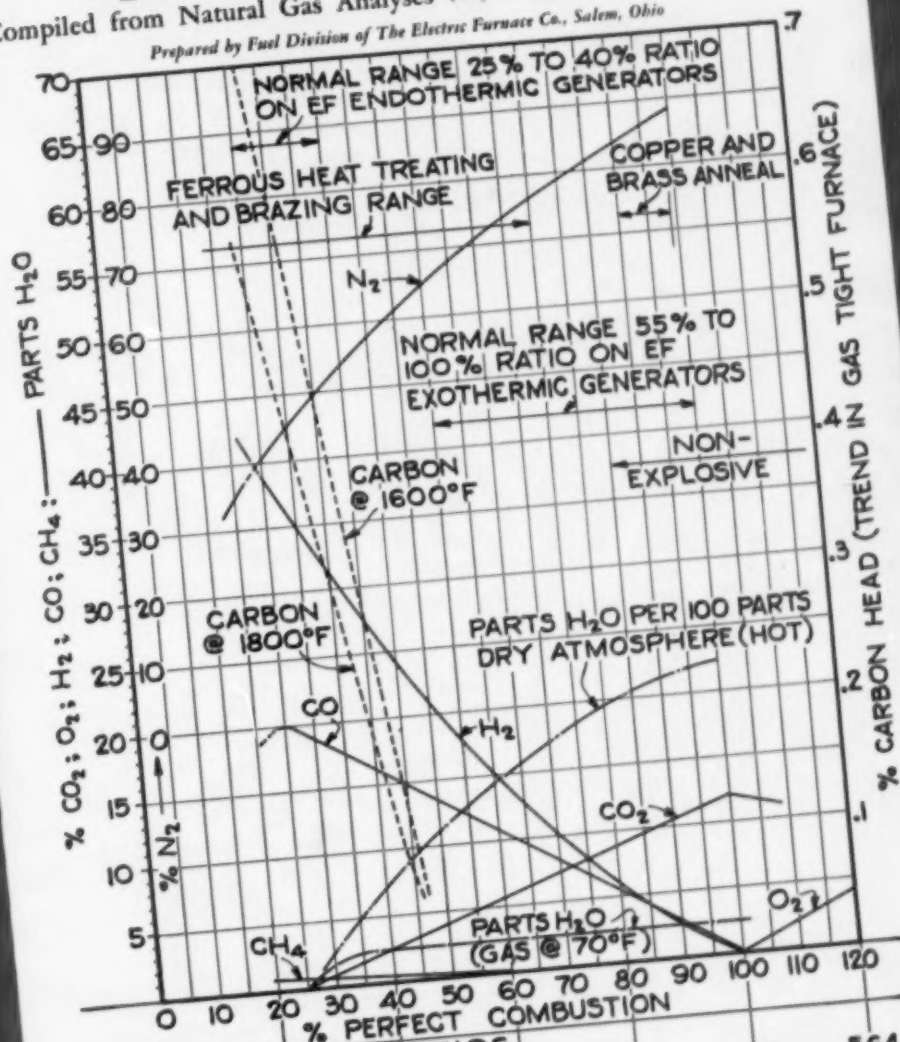
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Special Atmosphere Chart

Compiled from Natural Gas Analyses (City Gas and Propane Gas will be similar)
Prepared by Fuel Division of The Electric Furnace Co., Salem, Ohio



B.T.U. GAS	530	1030	2550	9.4	2	4.8	1.88	4.1	9.6	2.82	6.2	14.4	3.76	8.2	19.2	4.7	10.3	24	5.64	12.4	28.8
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Above percentages on gas atmosphere constituents have been averaged from many complete gas analyses. Actual gas analyses compared with above curves will vary slightly due to differences in generator temperature, catalyst, completeness of reaction, raw gas analysis and air-fuel ratio.

Carbon head determinations are obtained by running 801"x2"x2" carbon steel specimens, of high and low carbon, through a gas tight furnace. After exposure to gas atmosphere in furnace for at least twenty minutes (or until equilibrium is reached) the specimens are analyzed for carbon in chemical laboratory carbon furnace. About 8 specimens are required for one chemical analysis.

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